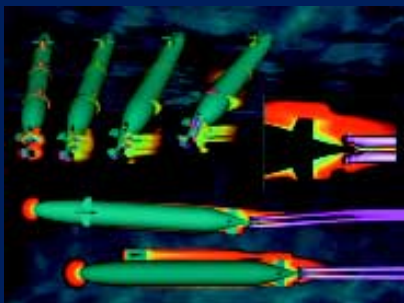
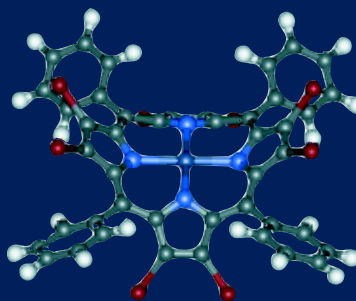
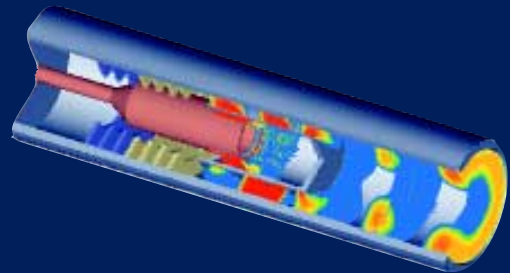
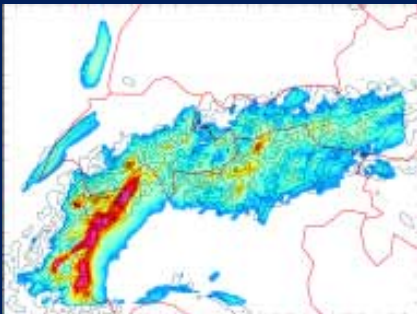
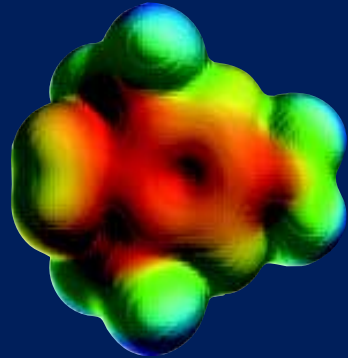


DoD HPC ***MODERNIZATION*** ***PROGRAM***

Modernization Plan 2000

**High
Performance
Computing**



**Supporting
the
Warfighter**

Front cover captions (clockwise starting from top right):

Quantum-mechanically derived electrostatic potential of the explosive TNT corresponding to the 0.001 electrons/bohr³ isosurface of electron density.

The geometry of a Magnetically Insulated Line Oscillator (MILO) and the radial electric field extremes in the extractor and waveguide regions of the device are shown in the figure.

The V-22 rotor-wake system is visualized in a post process where filaments of particles are released from inboard and outboard blade-tips every 25 time-steps.

Computed Structure of Zinc octabromo-meso-tetraphenylporphyrin.

Turning Maneuver Induced by a 10 Degree Rudder Deflection (Selected Views).

Frequency of gravity wave activity above the Alps for 1 October - 15 November 1999, expressed as a percentage of time, at 10 km amsl (color shading). The calculations are based on hourly output from COAMPS forecasts with a horizontal resolution of 5 km. The topography is shown in black contours and stippling, with the darkest representing elevations above 3000 m.

DEPARTMENT of DEFENSE
High PERFORMANCE Computing
MODERNIZATION PROGRAM
MODERNIZATION PLAN 2000



JUNE 2000



OFFICE OF THE DIRECTOR OF
DEFENSE RESEARCH AND ENGINEERING
3040 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3040

AUG 10 2000

High performance computing, a critical enabling technology, is changing the Department of Defense. Its use in detailed, high fidelity computational modeling and simulation results in improved research, expanded test envelopes, improved acquisition decisions, and improved analyses that were never before possible. The program directly supports over 5000 leading scientists and engineers who are using program assets as integral tools to assure our armed forces retain a technological advantage and force dominance on tomorrow's battlefield. This plan includes examples of the types of research, tests, and simulations made possible by high performance computing within the Defense Department. A more comprehensive presentation of project successes using high performance computing can be found in the 2000 edition of the High Performance Computing Technical Report Series, which will be published this fall.

I am pleased to present the 6th annual High Performance Computing Modernization Plan.

Sincerely,

A handwritten signature in dark ink, reading "Delores M. Etter", is positioned below the word "Sincerely,".

Delores M. Etter
Deputy Under Secretary of Defense
(Science and Technology)



EXECUTIVE SUMMARY

High performance computing historically has played a major role in the ability of the United States to develop and deploy superior weapons, warfighting capabilities, and mission support systems. Under the auspices of the Deputy Undersecretary of Defense (Science and Technology), the High Performance Computing Modernization Program continues to focus on acquiring, managing, and sustaining modern commercial high performance computing resources in support of the defense science and technology and test and evaluation communities.

The 2000 High Performance Computing Modernization Plan includes a program overview, several recent examples of defense projects successfully employing high performance computing, and a section on program accomplishments and future plans, with an emphasis on fiscal years 2000 and 2001. The overriding goal of the program continues to be the exploitation of high performance computing technology for military advantage across the battlespace. The strategy to achieve this goal remains that of acquiring and sustaining world-class high performance computing and network capabilities in support of defense scientists and engineers. The program supports over 600 high performance computing projects and the user base exceeds 5,000 scientists and engineers located at more than 100 Department of Defense laboratories, test centers, contractor and academic sites. Many of the leading edge, computationally intensive projects supported by the program are making critical contributions to high-priority warfighting systems; others are addressing research challenges fundamental to assuring defense technology competitiveness on the 21st century battlefield.

The program helps put advanced technology in the hands of U.S. forces more quickly, less expensively, and with greater certainty of success. Today's weapons programs, such as the V-22 Tiltrotor, Comanche Helicopter, the Medium Tactical Vehicle Replacement, and the Javelin Missile program have benefited through innovative materials, advanced design concepts, improved and faster modification designs, higher fidelity simulations and more efficient tests. Future weapons systems, such as radio frequency weapons, are benefiting through basic research in plasma physics, molecular engineering, high energy materials and advanced signal processing. Even though today's program has the resources to support only 50–60 percent of the program's validated high performance computing requirements, the projects that are supported are making a real difference in ensuring our warfighters are the best equipped in the world.

The use of high performance computing technology is reducing the costs and time required for systems analysis, design, development, test, and deployment; helping to avoid environmental damage; and improving the integration and effectiveness of complex weapons systems. As DoD continues to reform and reengineer its acquisition processes, high performance computing assets, along with high-fidelity scalable models and simulations, are being used to reduce the number and cost of building expensive prototypes. Increasingly, modeling and simulation are being used to explore more detailed design options and to identify important testing priorities earlier in the design cycle. High performance computing is now a key ingredient of the successful implementation of many major DoD acquisition programs.

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PROGRAM OVERVIEW

INTRODUCTION

The High Performance Computing Modernization Program (HPCMP) was initiated in 1993 in response to congressional direction to modernize the Department of Defense (DoD) laboratories' high performance computing (HPC) capabilities. Early on, senior leaders recognized the unique potential of this technology as critical to our nation's future defense. Today, the HPCMP fields world-class, commercial high performance computing capability, available to the full Science and Technology (S&T) and Test and Evaluation (T&E) communities, that includes a balanced set of major shared resource centers, smaller focused distributed centers, wide area networking services, and HPC software development support. Figure 1 shows the HPC center locations and Figure 2 depicts the integrated program strategy.

PROGRAM MISSION

The HPCMP mission is to provide world-class, commercial, high-end high performance computing capability to the DoD science and technology and test and evaluation communities, in order to allow our scientists and engineers to incorporate technological advantage into superior weapons, warfighting capabilities, and related support systems more rapidly and affordably with reduced risks to human life and optimized system performance.

PROGRAM VISION

The HPCMP vision is to enable the DoD to maintain its technological supremacy over adversaries of the United States in weapon systems design and to foster the flow of this technology into warfighting support systems, by providing world-class, commercial HPC capability to the science and technology and test and evaluation communities.

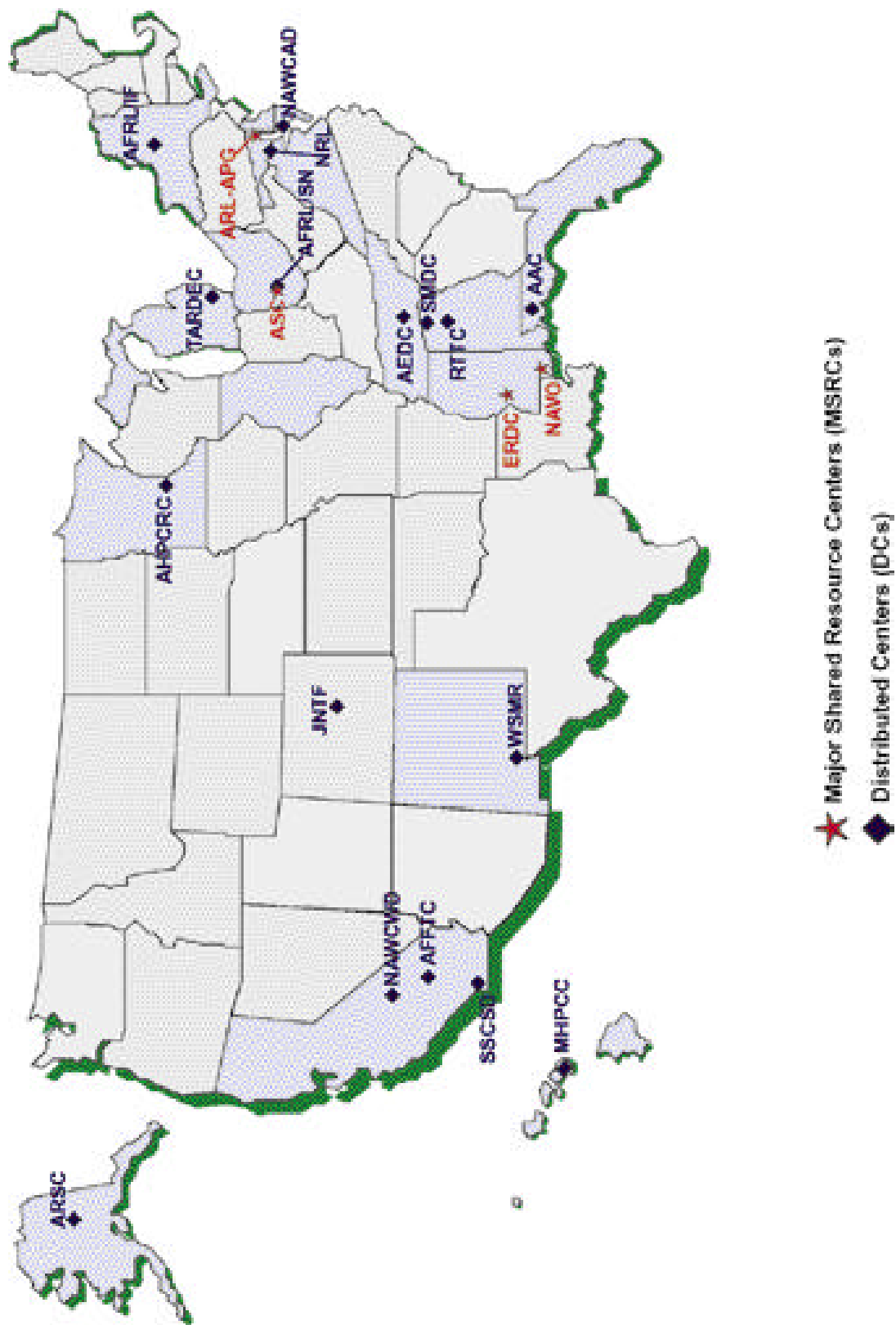


FIGURE 1. High Performance Computing Centers

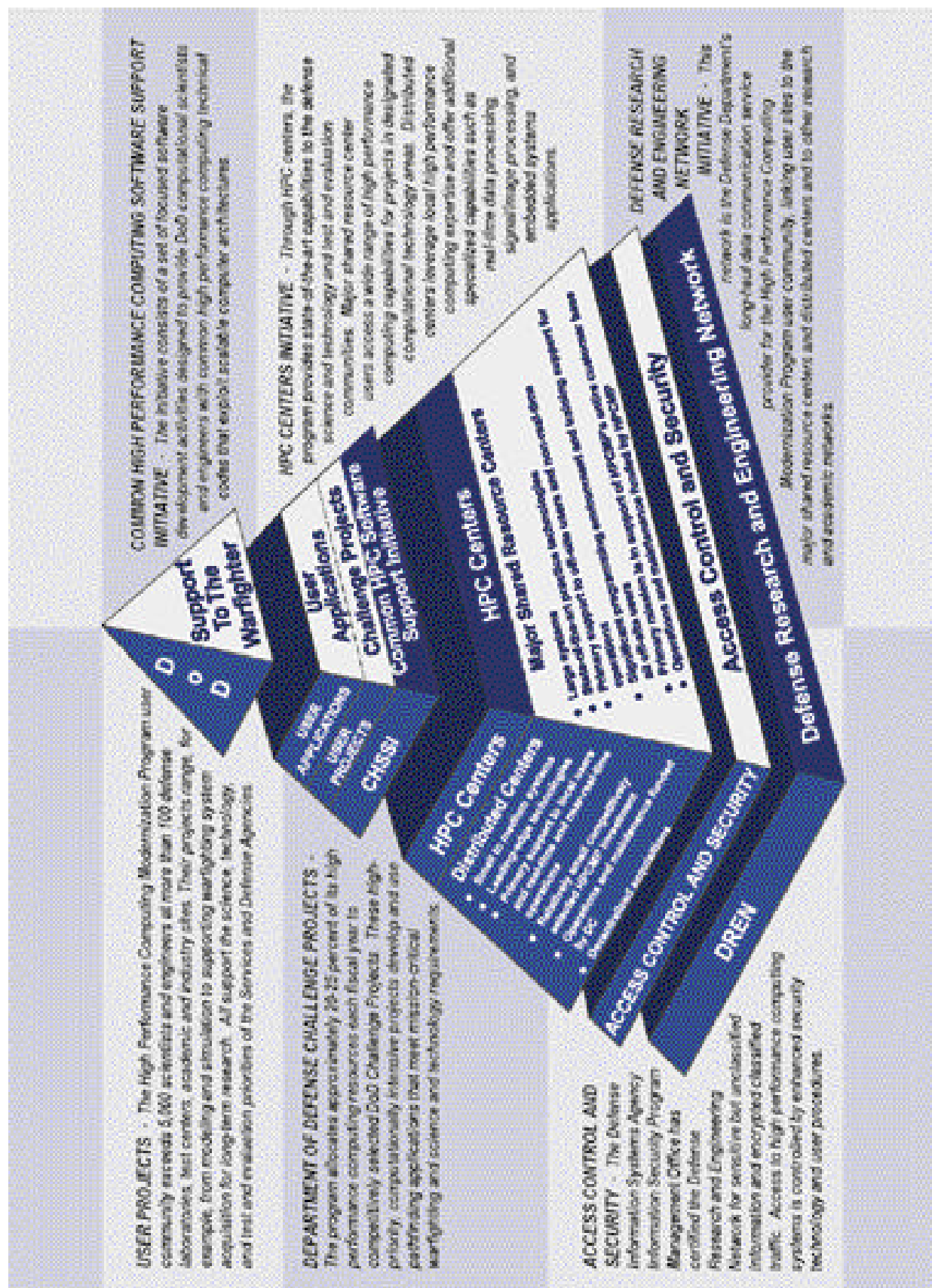


FIGURE 2. INTEGRATED PROGRAM STRATEGY OF THE DEPARTMENT OF DEFENSE HIGH PERFORMANCE COMPUTING MODERNIZATION PROGRAM

PROGRAM SCOPE

The HPCMP scope is bounded both in terms of the user community it serves and the technological capability that it delivers. By limiting the scope and by concentrating the majority of resources at a small number of HPC centers, the program has been able to provide world-class, commercial computing capabilities that could not have efficiently been obtained and sustained by individual Services or Agencies. This sharing of resources reduces overall acquisition and sustainment costs and fosters collaboration and cooperation across the DoD S&T and T&E communities.

The scope of the user community is defined by the Congress (Public Law 104-61, December 1, 1995, 109 Statute 665, Sec. 8073) to be

“(1) the DoD Science and Technology sites under the cognizance of the DDR&E, (2) the DoD Test and Evaluation centers under the Director, Test and Evaluation OUSD (A&T), and (3) the Ballistic Missile Defense Organization.”

From a technology capability perspective, the program maintains a strict focus on providing high performance computing. The definition of “high performance computing” changes as the technology continues to evolve. This consistent evolution requires that the program periodically reassess its acquisition plans to ensure that it is not acquiring systems which have become “departmental” class. Departmental class systems remain the responsibility of the local organization. The rapid evolution of high performance computing also requires that the program focus on delivering improved capability early in its life cycle. This allows the DoD to maintain the technological edge required to analyze, design, produce and deploy advanced weapons systems and capabilities to the warfighter — before similar computational capabilities are available to our adversaries and economic competitors.

USER REQUIREMENTS

From its inception, the HPCMP was designed to address the continuing high-end computing needs of the DoD S&T program. Congress later amended the program scope to include the T&E community creating its current user base of over 5,000 scientists and engineers located at more than 100 DoD laboratories, test centers, contractor and academic sites. The program office, working with representatives of the user community, identify and track requirements at the computational project level.

USER REQUIREMENTS— CONTINUED

The requirements process, developed and employed by the program, includes an annual survey sent to users and potential users throughout the DoD S&T and T&E communities, coupled with visits to selected sites to discuss requirements and to provide information to user groups. In addition, the program obtains feedback through user satisfaction surveys, annual user group meetings, and advisory panels that work with program representatives to establish policies and procedures at the HPC centers.

HPC systems performance metrics are tracked throughout the year at the computational project level to ensure projects receiving allocations are indeed able to use the resources effectively and efficiently. This process provides feedback to the Services and Agencies prior to allocating resources the following fiscal year. The overall integrated process, linked at the computational project level, furnishes accurate and timely data on which to base program decisions.

Twenty to twenty-five percent of the program's total resources are dedicated each year to a set of DoD HPC Challenge Projects. These computationally intensive, high-priority projects are selected annually through a rigorous technical and mission relevance evaluation. The remaining resources are allocated by Services and Agencies according to their prioritized needs. Table 1 provides a few examples of HPC projects and their value to the warfighting community.

COMPUTATIONAL TECHNOLOGY AREAS

The DoD HPCMP user community is organized around ten broad computational technology areas (CTAs). Each computational technology area has a designated leader who is a prominent DoD scientist or engineer working within the research disciplines included in his or her area. Table 2 provides a brief description of each CTA. Table 3 lists the current CTA leaders.

Teams of leading defense scientists and engineers use HPC resources to develop, advance, maintain, and use hundreds of scientific algorithms, codes, models and simulations needed to analyze, design, develop, test, evaluate and deploy technologically superior weapons, warfighting capabilities, and related support systems. Their efforts produce and support key enabling technologies, capabilities, and demonstrations articulated by the Defense Technology

TABLE 1. Examples of High Performance Computing Projects and Their Value to the Warfighter

Projects	Value to the Warfighter and Joint Warfighting Capability Objectives Supported
3-D Computational Fluid Dynamics (CFD) Modeling of the Chemical Oxygen-Iodine Laser	Provides the Air Force Space-based Laser (SBL) program with data to assist in developing an advanced nozzle for increased performance. Impacts the Airborne Laser (ABL) development program by providing high quality, high fidelity simulations of chemical laser devices in a timely manner. (<i>Precision Force</i>)
Applied CFD in Support of Aircraft-Store Compatibility and Weapons Integration	Enables the performance of numerical simulations to determine store loads, store separation characteristics, and trajectories. Provides flight clearances and certification recommendations that translate into an operational capability. (<i>Joint Readiness and Logistics, and Sustainment of Strategic Systems</i>)
Coupled Environmental Model Prediction (CEMP)	Enables development of coupled ocean/ice/air prediction models to provide forecasts in the battle space environment. (<i>Joint Readiness and Logistics, and Sustainment of Strategic Systems</i>)
Development of Standards for Stand-Off Distance and Blast Walls for Force Protection	Enables development of standards for standoff distances and blast wall designs for survivable bases and facilities to meet force protection needs. Enhances the design of barriers or blast walls to shield or protect vulnerable compounds and structures and advance protective construction technology. (<i>Combating Terrorism</i>)
Global and Basin-Scale Ocean Modeling and Prediction	Provides ocean models and capability to the Fleet Numerical Meteorology and Oceanography Center that furnishes daily atmospheric and oceanographic forecasts for the operational Navy. (<i>Joint Readiness and Logistics, and Sustainment of Strategic Systems</i>)
High-Resolution Adaptive Mesh Refinement (AMR) Simulations of Confined Explosions	Provides input to military strategy for counter-proliferation measures. Aids forensic investigations of terrorist bombing incidents. Suggests methods of protecting civilians and US troops. (<i>Combating Terrorism</i>)
Modeling Complex Projectile Target Interactions	Increase ballistic protection of ground combat vehicles and increase munitions lethality. (<i>Precision Force</i>)
Parallel Simulations of Weapon/Target Interactions Using a Coupled CFD/Computational Structural Dynamics (CSD) Methodology	Improves counter-terrorism and force-protection activities. Aids in the forensic analysis following an attack. Supports better targeting of weapons-of-mass-destruction facilities by improved blast-damage assessment tools. (<i>Force Protection</i>)
Unsteady Aerodynamics of Advanced Guided Munitions	Reduces design costs and provides a more detailed understanding of the complex aerodynamics than can be achieved through experiment and actual test firings. (<i>Joint Readiness and Logistics, and Sustainment of Strategic Systems</i>)
Virtual Prototyping of Radio Frequency (RF) Weapons	Enables detailed modeling of directed energy radio frequency (RF) weapons, which are expected to play a large role in controlling the battlefield of the 21st century. (<i>Precision Force</i>)

TABLE 2. COMPUTATIONAL TECHNOLOGY AREAS

<p>Computational Structural Mechanics (CSM) provides high resolution, multi-dimensional modeling of materials and structures subjected to a broad range of static, dynamic, and impulsive loading conditions. Uses include affects of explosions on various facilities, underwater explosion and ship response, structural acoustics, structural analysis, propulsion systems, lethality and survivability (aircraft, ships, submarines, tanks), theater missile defense, and real-time, large-scale soldier and hardware in-the-loop vehicle dynamics.</p>	<p>Signal/Image Processing (SIP) provides for extraction and analysis of key real-time information from various sensor outputs. Sensors include sonar, radar, visible and infrared imagers, and signal intelligence and navigation assets. Uses include intelligence, surveillance and reconnaissance (ISR), avionics, communications, smart munitions, and electronic warfare. Functions include detecting, tracking, classifying, and recognizing targets in the midst of noise and jamming; generating high-resolution low-noise imagery; and the compression of imagery for communications and storage.</p>
<p>Computational Fluid Dynamics (CFD) provides the accurate numerical solution of the equations describing fluid and gas motion and fluid-dynamics research. Uses include the design of complex combustion and propulsion systems that are inaccessible or too costly to prototype; the dynamics of submarines, subsonic, transonic and supersonic air vehicles, pipe flows, air circulation, missiles, and projectiles; and magnetohydrodynamics for advanced power systems and weapons effects.</p>	<p>Forces Modeling and Simulation (FMS)/C4I integrates high speed command, control, communications, computers and intelligence systems (C4I) to manage a battle space; provides large-scale simulations of complex military engagements to facilitate mission rehearsal/training, mission planning, and post-mission analysis; and advances digital library technology for support of FMS/C4I research and development activities. Uses span the design, development, test, evaluation, and deployment of a variety of warfighting and training systems.</p>
<p>Computational Chemistry and Materials Science (CCM) predicts properties of chemical species and applies this molecular understanding to development of advanced materials. Uses include design of new chemical compounds for fuels, lubricants, explosives, rocket propellants and chemical defense agents. In addition, advanced modeling techniques are used to develop new high performance materials for electronics, advanced sensors, engines, laser protection systems, engine components, and biomedical applications.</p>	<p>Environmental Quality Modeling and Simulation (EQM) provides high-resolution, three-dimensional Navier-Stokes modeling of hydrodynamics and contaminant transport through air, ground and aquatic ecosystems. Uses include stewardship and conservation of natural and cultural resources, prediction of chemical, biochemical contaminant flows, design and operation of installation restoration, integrated management in support of environmental quality, noise evaluation and abatement, and water quality models.</p>
<p>Computational Electromagnetics and Acoustics (CEA) provides high-resolution, multi-dimensional solutions of Maxwell's equations and acoustic wave equations. Uses include calculating fields about antenna arrays; signatures of tactical ground, air, sea and space vehicles; the signature of buried munitions; performance/design factors for electromagnetic gun technology; high power microwave performance; modeling of acoustic fields for surveillance and communication; seismic fields for mine detection; and acoustic shock waves of explosions for anti-personnel weapons.</p>	<p>Computational Electronics and Nanoelectronics (CEN) provides the design, modeling, and simulation of complex electronic devices, integrated circuits, and small components. Uses include lower costs, weights, size and improved performance of electronics through predictive high-fidelity modeling and simulation; analog/digital high-frequency circuit and device simulation and optimization; modeling and simulation of micro-electromechanical devices, micro-resonators, active and passive millimeter-wave circuits and structures; electronic/photonic interconnect and packaging analysis; and fault modeling.</p>
<p>Climate/Weather/Ocean Modeling and Simulation (CWO) provides the numerical simulation and forecast of the earth's climate as well as oceanic and atmospheric variability. Uses include improved flight safety; search-and-rescue mission planning; propagation of weapons; aircraft and ship routing; anti-submarine and undersea warfare; enhanced capabilities in adverse weather; capability to predict magnetic storm-induced effects; and outages on command, control, communications (C3), surveillance, and navigation systems.</p>	<p>Integrated Modeling and Test Environments (IMT) applies high performance computing software tools and techniques with live tests and hardware-in-the-loop simulations for test and evaluation of DoD weapons, components, subsystems, and systems in virtual and composite virtual/real environments. Uses include digital scene generation, six degree-of-freedom trajectory simulations, real-time test-data analysis and display systems for test control and evaluation, and high fidelity engineering and closed-loop engagement models (one-on-one and few-on-few).</p>

COMPUTATIONAL TECHNOLOGY AREAS— CONTINUED

Objectives (DTOs). These enabling DTOs, in turn, support Joint Vision 2020 and the eleven Joint Warfighting Capability Objectives (JWCs) promulgated by the Joint Requirements Oversight Council of the Joint Chiefs of Staff.

While not all-inclusive, JWCs provide focus, priority, and a common reference point for much of the DoD's research, test and evaluation efforts. They are described in detail in the annual Joint Warfighting Science and Technology Plan (JWSTP).

Figure 3 depicts the interrelationships among Joint Vision 2020, the JWCs, the DTOs, and the CTAs. In most cases, each CTA supports multiple DTOs and JWCs. Likewise, individual DTOs and JWCs are supported by multiple CTAs.

TABLE 3. COMPUTATIONAL TECHNOLOGY AREA LEADERS

Computational Technology Areas	Leaders
Computational Structural Mechanics	Dr. Raju Namburu Army Research Laboratory, Aberdeen Proving Ground, MD
Computational Fluid Dynamics	Dr. Jay Boris Naval Research Laboratory, Washington, DC
Computational Chemistry and Materials Science	Dr. Leslie Perkins Air Force Research Laboratory, Propulsion Directorate, Edwards Air Force Base (AFB), CA
Computational Electromagnetics and Acoustics	Dr. Robert Peterkin Air Force Research Laboratory, Directed Energy Directorate, Kirtland AFB, NM
Climate, Weather, and Ocean Modeling and Simulation	Dr. George Heburn Naval Research Laboratory, John C. Stennis Space Center, MS
Signal/Image Processing	Dr. Richard Linderman Air Force Research Laboratory, Information Directorate, Rome, NY
Forces Modeling and Simulation/C4I	Mr. Robert Wasilausky Space and Naval Warfare Systems Center, San Diego, CA
Environmental Quality Modeling and Simulation	Dr. Jeffrey Holland Engineer Research and Development Center, Vicksburg, MS
Computational Electronics and Nanoelectronics	Dr. Barry Perlman Army Communications-Electronics Command Research Development and Engineering Center, Ft. Monmouth, NJ
Integrated Modeling and Test Environments	Dr. Andrew Mark Army Research Laboratory, Aberdeen Proving Ground, MD

FIGURE 3. INTERRELATIONSHIPS AMONG THE OPERATIONAL CONCEPTS, CAPABILITY AND TECHNOLOGY OBJECTIVES AND THE HPCMP COMPUTATIONAL TECHNOLOGY AREAS



JOINT VISION 2020 EMERGING OPERATIONAL CONCEPTS

The High Performance Computing Modernization Program supports the concepts defined by the Joint Chiefs of Staff's *Joint Vision 2020*:

- Dominant Maneuver
- Precision Engagement
- Full-Dimensional Protection
- Focused Logistics
- Information Superiority
- Technological Innovation

JOINT WARFIGHTING CAPABILITY OBJECTIVES

The program supports 11 Joint Warfighting Capability Objectives defined by the Joint Chiefs of Staff. These represent some of the most critical capabilities for maintaining the warfighting advantage of U.S. forces:

- Information Superiority
- Precision Force
- Combat Identification
- Joint Theater Missile Defense
- Military Operations in Urbanized Terrain
- Joint Readiness and Logistics and Sustainment of Strategic Systems
- Force Projection/Dominant Maneuver
- Electronic Warfare
- Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction
- Combating Terrorism
- Protection of Space Assets

DEFENSE TECHNOLOGY OBJECTIVES

The program supports most of the 347 Defense Technology Objectives (DTOs) as set forth in the *Defense Technology Area Plan* and the *Joint Warfighting Science and Technology Plan*. The DTOs are defined by technology managers and program managers. These objectives identify specific technology advancements to be developed or demonstrated in the following 11 categories:

- Air Platforms
- Chemical/Biological Defense
- Information Systems Technology
- Ground and Sea Vehicles
- Materials/Processes
- Biomedical
- Sensors, Electronics, and Battlespace Environment
- Space Platforms
- Human Systems
- Weapons
- Nuclear Technology

COMPUTATIONAL TECHNOLOGY AREAS

The program supports defense science and technology and test and evaluation efforts in ten broad computational technology areas:

- Computational Structural Mechanics
- Computational Fluid Dynamics
- Computational Chemistry and Materials Science
- Computational Electromagnetics and Acoustics
- Climate, Weather, and Ocean Modeling and Simulation
- Signal/Image Processing
- Forces Modeling and Simulation/C4I
- Environmental Quality Modeling and Simulation
- Computational Electronics and Nanoelectronics
- Integrated Modeling and Test Environments

PROGRAM GOALS

The program provides an increasingly powerful, high-end, high performance computing environment and has the following goals:

- (1) Continually acquire the best commercially available high-end HPC systems.
 - (2) Acquire and develop common-use software tools and programming environments.
 - (3) Expand and train the DoD high performance computing user base.
 - (4) Link users and computer sites via high-speed networks, facilitating the creation of collaborative work environments.
 - (5) Exploit the best ideas, algorithms, and software tools emerging from the national high performance computing infrastructure.
-

PROGRAM STRATEGIES

The program implements the following strategies to achieve the five program goals:

Goal 1 — Provide the best commercially available high-end HPC capability.

- Provide a balanced set of commercially available heterogeneous computing platforms and HPC systems to meet the full range of DoD requirements and permit the optimum mapping of requirements to system types.
- Build complete HPC environments, including large computing systems, software, and support expertise at a few DoD laboratories designated as major shared resource centers (MSRCs) to support a wide community of users.
- Place modest-sized HPC systems at selected distributed centers (DCs) when that allows for either innovation or mission support not provided by a major shared resource center.
- Support efforts to build complementary HPC capabilities and technologies throughout government, academia, and industry that are applicable to defense S&T and T&E requirements.
- Continually acquire and upgrade equipment and support services to ensure that DoD HPC centers provide world-class, commercial, state-of-the-art capabilities.

PROGRAM STRATEGIES— CONTINUED

Goal 2 — Acquire and develop common-use software tools and programming environments.

- Promote standards for defense research, development, test, and evaluation software to ensure future transitions and advancements in software technology are applied in an efficient, cost-effective manner.
- Focus on applications software initiatives designed to overcome technological inhibitors that may delay the effective use of scalable high performance computers.
- Support software components used in specific computational technology areas or by a subset of HPC users across the community.
- Identify software suites to be shared across major shared resource centers and selected distributed centers.

Goal 3 — Expand and train the DoD high performance computing user base.

- Provide user education in scalable computer and computational sciences, software applications and optimization, and code conversion.
- Promote the formation of DoD-sponsored interdisciplinary teams and collaborative groups to determine how best to support each computational technology area and to leverage academia and industry expertise in HPC for the solution of DoD problems.
- Develop shared application software in support of high-priority and broadly-based computational technology area needs.
- Aggressively transfer expertise and knowledge among the DoD HPC user communities.
- Broaden the knowledge base of the DoD HPC user community based on new applications and their capabilities.

Goal 4 — Link users and computer sites via high-speed networks, facilitating the creation of collaborative work environments.

- Deploy robust and cost effective network connectivity consistent with HPC traffic requirements among and between DoD scientists and engineers and HPC assets, and between the DoD and external research and test and evaluation communities.

PROGRAM STRATEGIES— CONTINUED

- Encourage remote usage where appropriate.
- Ensure users and the highest priority projects are well supported.

Goal 5 — Exploit the best ideas, algorithms, and software tools emerging from the national high performance computing infrastructure.

- Ensure that users in the defense science and technology and test and evaluation communities remain cognizant of, interact with, and leverage internal Defense Department initiatives.
- Ensure that defense science and technology and test and evaluation users remain cognizant of, collaborate with, and leverage other government, academia, industry, and each other's HPC efforts.
- Maintain cooperative contact with the appropriate committees, subcommittees, working groups, and advisory panels associated with the National Science and Technology Committee structure.
- Maintain cooperative contact with the Department of Energy Accelerated Strategic Computing Initiative.
- Provide HPC resources to support defense applications that directly relate to dual-use technologies and National Challenges, such as environment, medical, digital libraries, and manufacturing processes and products.
- Ensure the availability of HPC resources to support defense applications that address DoD HPC Challenge Project needs.
- Leverage the nation's HPC infrastructure to benefit the warfighter.

PROGRAM INITIATIVES

Three initiatives implement the program strategies, outlined previously, to achieve its goals. The initiatives are HPC centers, Networking, and the Common High Performance Computing Software Support Initiative (CHSSI). The initiatives improve the ability of users to analyze, develop, and deploy advanced weapons, warfighting capabilities, and related support systems more rapidly and affordably with reduced risk to human life and with optimal system

PROGRAM INITIATIVES— CONTINUED

performance. The initiatives align to program goals as follows:

	HPC Centers	Networking	Software Support
Goal 1	X		
Goal 2	X		X
Goal 3	X	X	X
Goal 4		X	
Goal 5	X	X	X

High Performance Computing Centers

Major Shared Resource Centers

The HPCMP operates four large major shared resource centers to enable the DoD S&T and T&E communities to effectively and efficiently use the full range of high-end HPC resources. Each MSRC is operated and maintained by a team of government and contractor personnel. The four MSRCs are:

- Aeronautical Systems Center (ASC), Wright-Patterson AFB, OH
- Army Research Laboratory (ARL), Aberdeen Proving Ground, MD
- Army Engineer Research and Development Center (ERDC), Vicksburg, MS
- Naval Oceanographic Office (NAVO), John C. Stennis Space Center, MS

Each MSRC includes a robust complement of high-end high performance computing and communications systems, scientific visualization capabilities, peripheral and archival mass storage devices, and support staff providing expertise in the use of these assets. The MSRC emphasis is on supporting large computational projects. As shown in Table 4, each center's hardware configurations, software, programming environments, and training efforts are focused to best support the needs of a particular set of CTAs designated for that center.

PROGRAM INITIATIVES— CONTINUED

A key element of support at each MSRC is the Programming Environment and Training (PET) effort. This effort, in addition to providing extensive training to meet a wide variety of user needs, supports incorporation of state-of-the-art system tools and HPC technology to facilitate the effective and efficient use of the various HPC systems. This support is accomplished through collaborative partnerships established by each MSRC with several leading civilian HPC centers and academic institutions. Such rapid collaboration fosters the capture of innovation and draws additional high performance computing technology and expertise into the DoD. MSRCs also focus on training the DoD user base, identifying HPC technology opportunities, and introducing these opportunities into all HPC centers' computing environments.

DISTRIBUTED CENTERS

Distributed centers (DCs) provide HPC capability to a specified local and remote portion of the HPC user community. Modest-sized systems are deployed to DCs where there is a significant advantage to having a local HPC

TABLE 4. COMPUTATIONAL TECHNOLOGY AREA SUPPORT AT MSRCs

Computational Technology Areas	ASC	ARL	ERDC	NAVO
Computational Structural Mechanics	x	x	x	
Computational Fluid Dynamics	x	x	x	x
Computational Chemistry and Materials Science	x	x		
Computational Electromagnetics and Acoustics	x			x
Climate, Weather, and Ocean Modeling and Simulation			x	x
Signal/Image Processing		x		x
Forces Modeling and Simulation/C4I		x	x	
Environmental Quality Modeling and Simulation			x	x
Computational Electronics and Nanoelectronics	x			
Integrated Modeling and Test Environments		x		

**PROGRAM INITIATIVES—
CONTINUED**

system and where there is a unique potential for advancing DoD applications. DCs leverage HPC expertise or address problems that cannot be readily solved at the MSRCs, such as real-time or near real-time processing, embedded system applications, and man-in-the-loop and hardware-in-the-loop testing and evaluation. The centers are linked by high-speed communications to the MSRCs and remote users. Thus, they augment the MSRCs to form the total DoD HPCMP computational capability. The seventeen DCs are:

- Air Armament Center (AAC), Eglin AFB, FL
- Air Force Flight Test Center (AFFTC), Edwards AFB, CA
- Air Force Research Laboratory, Information Directorate (AFRL/IF), Rome, NY
- Air Force Research Laboratory, Sensors Directorate (AFRL/SN), Wright-Patterson AFB, OH
- Arctic Region Supercomputing Center (ARSC), Fairbanks, AK
- Army High Performance Computing Research Center (AHPCRC), Minneapolis, MN
- Arnold Engineering Development Center (AEDC), Arnold AFB, TN
- Joint National Test Facility (JNTF), Schriever AFB, CO
- Maui High Performance Computing Center (MHPCC), Kihei, HI
- Naval Air Warfare Center Aircraft Division (NAWCAD), Patuxent River, MD
- Naval Air Warfare Center Weapons Division (NAWCWD), China Lake, CA
- Naval Research Laboratory (NRL-DC), Washington, DC
- Redstone Technical Test Center (RTTC), Huntsville, AL
- Space and Missile Defense Command (SMDC), Huntsville, AL
- Space and Naval Warfare Systems Center (SSC-SD), San Diego, CA
- Tank Automotive Research, Development and Engineering Center (TARDEC), Warren, MI
- White Sands Missile Range (WSMR), White Sands Missile Range, NM

PROGRAM INITIATIVES— CONTINUED

Networking

DEFENSE RESEARCH AND ENGINEERING NETWORK

The Defense Research and Engineering Network (DREN) is a Defense Department data communications network. Figure 4 graphically displays the DREN connections for the program's high performance computing centers, and other wide area network access points. The program's users require reliable, leading edge, high-speed access to HPC resources. DREN satisfies this need by providing wide area networking (WAN) services through a virtual private network using a public Asynchronous Transfer Mode (ATM) communications infrastructure supplied by American Telephone & Telegraph (AT&T). High-speed remote connectivity is especially important to our 3,500 remote users.

Providing wide area access over a commercial ATM infrastructure has distinct advantages. Connecting and disconnecting sites from the network and changing service levels can be accomplished easily. Because DREN uses commercial services, the most advanced networking technology can be used as soon as it becomes available in the commercial sector. Therefore, costs are minimized by eliminating the need for a large staff to maintain and operate legacy data communications systems.

With this arrangement, DREN provides HPC users with transparent access to and from other commercial Internet service providers while maintaining traditional federal peering relationships with other government agencies. Peering allows networks to exchange routing information directly, thereby enabling the most efficient path for transmitting data. DREN has also established important peering initiatives with new federal network initiatives such as the Next Generation Internet (NGI), the Internet 2 ABILENE project, and the National Science Foundation's very high performance Backbone Network Service (vBNS).

DREN provides interoperable ATM and Internet Protocol (IP) services for digital video, audio, imaging, and data. Currently network access capabilities range from T3 (45 million bits per second) to OC-12c (622 million bits per second) with OC-48c (2.4 billion bits per second) available by 2001. DREN fully supports evolving protocols such as multicasting. State-of-the-art National Security Agency (NSA) approved security technology encrypts and protects HPC classified data transmissions across the WAN. As HPCMP

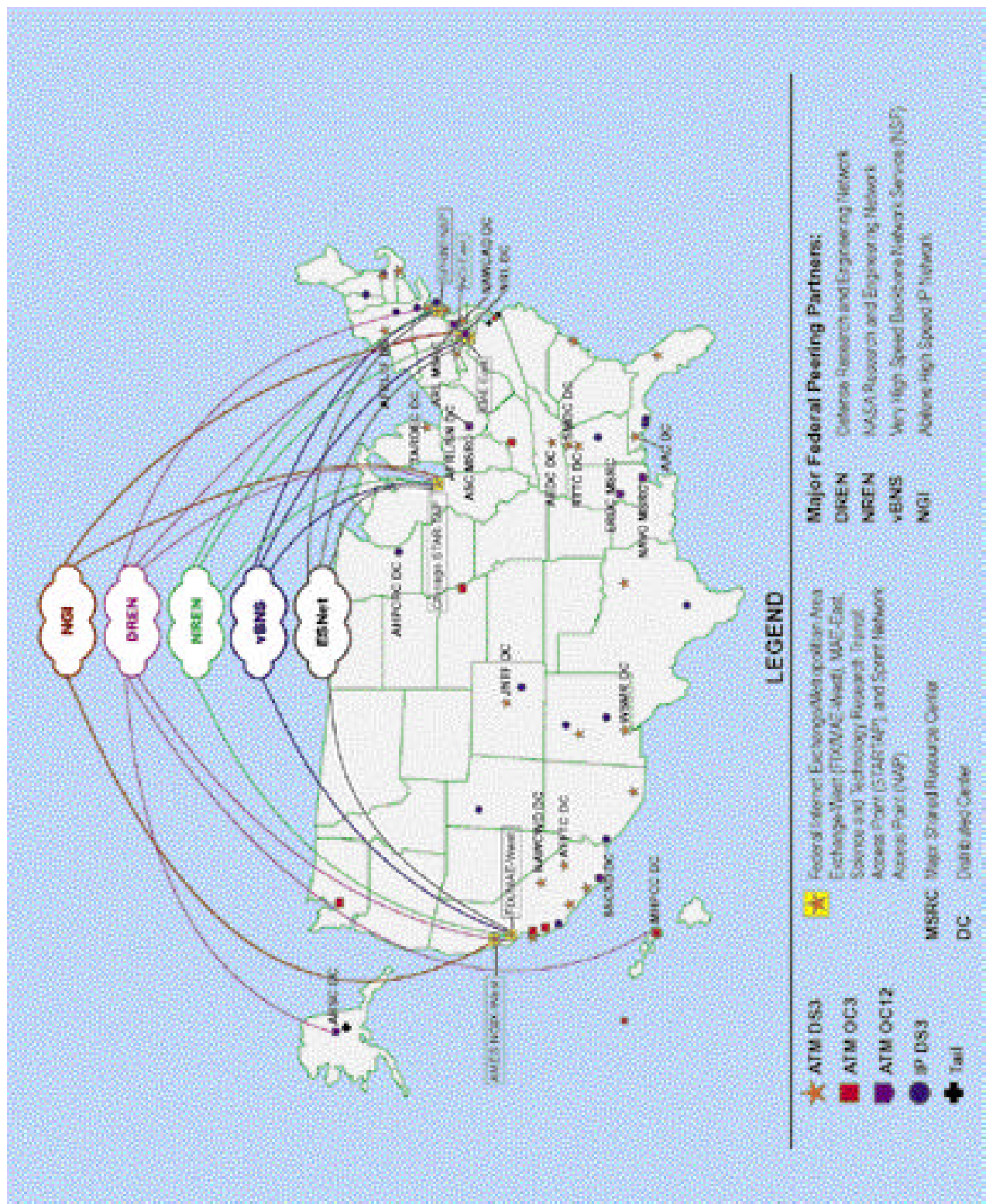


FIGURE 4. DREN CONNECTIONS, SHARED RESOURCE CENTERS, AND OTHER NETWORK ACCESS POINTS

PROGRAM INITIATIVES— CONTINUED

networking requirements continue to evolve, DREN will continue to provide the best commercially available support for applications such as distributed computing, remote training, distance learning, virtual workshops, and remote interactive visualization.

SECURITY

HPCMP security is implemented at both the HPC site level, to protect HPC resources and users, and at the network level for the HPC community.

The security posture of all HPC sites is verified before they are authorized to connect to the DREN. While the HPCMP retains overall security policy and oversight responsibilities, security certification and accreditation are done at the individual site level with accreditation delegated to the host Services. Certifying user sites is also delegated to the host Services while the HPCMP is responsible for certification of HPC centers. HPC center certification is performed by a security test and evaluation (ST&E) team led by the Defense Information Systems Agency (DISA). The HPCMP also performs Site Assistance Visits (SAVs) on an annual basis and periodically sponsors independent National Security Agency Security Assessments.

HPC centers and user sites that have classified computing requirements are accredited and certified at the appropriate classification level. The HPCMP requires that copies of memorandums of agreement, in accordance with Department of Defense Directive 5200.28, are on file before allowing classified communications between user and provider sites. All communications are accomplished using Type 1 National Security Agency approved encryption devices.

For unclassified processing, the HPCMP requires strong identification authentication to ensure that only authorized users are allowed access to HPC resources. Strong authentication is implemented using a combination of Kerberos software, one-time passcodes (currently SecureID cards), and Secure Shell software. This increases protection from:

**PROGRAM INITIATIVES—
CONTINUED**

- disruption of service to authorized users;
- unauthorized disclosure, copying (theft), or alteration of users' data;
- unauthorized access to HPC centers' computers; and
- misuse of HPC centers' computers.

At the network level, the HPCMP monitors all HPC centers and is preparing to monitor the DREN network access points where connections to other networks are made. Monitoring is done using network intrusion detection systems (NIDS) running Department of Energy developed Joint Intrusion Detection (JID) and other software and is performed by the HPC Computer Emergency Response Team (CERT), which is currently operated by the DISA Regional Network Operations and Security Center in Columbus, OH. Access control lists on network devices are used to further protect DREN users from known sources of attack. The HPCMP also works closely with other DoD organizations to ensure that the DREN and all connected sites meet Service and Office of the Secretary of Defense security regulations and requirements.

**COMMON HIGH PERFORMANCE COMPUTING
SOFTWARE SUPPORT INITIATIVE**

The Common High Performance Computing Software Support Initiative (CHSSI) provides efficient, scalable, portable software codes, algorithms, tools, models and simulations that run on a variety of HPC platforms and are needed by a large number of S&T and T&E scientists and engineers. CHSSI is organized around the ten CTAs and involves approximately 5,000 scientists and engineers working in close collaboration across government, industry and academia. CHSSI teams include algorithm developers, applications specialists, computational scientists, computer scientists and engineers, and end users.

Developing software for scalable HPC systems remains a technically challenging and labor intensive effort. CHSSI is helping the DoD take advantage of existing and future computing and communications capabilities by building software with an emphasis on reusability, scalability, portability and maintainability. In addition, CHSSI is producing a new generation of world-class scientists and engineers trained in

**PROGRAM INITIATIVES—
CONTINUED**

scalable software techniques that will reduce the future costs of doing business and increase our future defense capabilities. Table 5 lists the current 35 CHSSI projects and principal investigators across the CTAs.

**TABLE 5. COMMON HPC SOFTWARE SUPPORT INITIATIVE PROJECTS AND PRINCIPAL INVESTIGATORS
(FISCAL YEAR 2000)**

Project	Principal Investigator	Organization
Computational Structural Mechanics		
A Next Generation Scalable Finite Element Software to Describe Fracture and Fragmentation of Solids and Structures	Dr. A.M. Rajendran	Army Research Laboratory, Aberdeen Proving Ground, MD
Scalable Algorithms for Shock Physics	Mr. Kent Kimsey	Army Research Laboratory, Aberdeen Proving Ground, MD
Computational Fluid Dynamics		
FAST3D (Global Virtual-Cell Embedding Gridding)	Dr. Jay Boris	Naval Research Laboratory, Washington, DC
COBALT (Unstructured Gridding)	Mr. Bill Strang	Air Force Research Laboratory, Wright-Patterson AFB, OH
FEFLO (Unstructured Gridding)	Dr. Bill Sandberg	Naval Research Laboratory, Washington, DC
OVERSET (Chimera Gridding)	Dr. Bob Meakin	Army-Aviation Missile Command, Ames Research Center, Moffett Field, CA
Scalable CFD Simulation System for Complex Bodies in Relative Motion	Mr. Jere Matty	Arnold Engineering Development Center, Arnold AFB, TN
SUPREM DSMC: Scalable, Parallel, Reacting, Multidimensional Direct Simulation Monte Carlo Flow Code	Dr. Ingrid Wysong	Air Force Research Laboratory, Propulsion Directorate, Edwards AFB, CA
Computational Chemistry and Materials Science		
Car-Parinello Methods for Solids	Dr. David Singh	Naval Research Laboratory, Washington, DC
Quantum Chemistry	Dr. Jerry Boatz	Air Force Research Laboratory, Edwards AFB, CA
Fast Parallel Total Energy Methods for Multiple Length Scales	Dr. Dimitrios Papaconstantopoulos	Naval Research Laboratory, Washington, DC
Molecular Dynamics for Energetic and Non-Energetic Materials	Dr. Leslie Perkins	Air Force Research Laboratory, Propulsion Directorate, Edwards AFB, CA
Classical Molecular Dynamics	Dr. Ruth Pachter	Air Force Research Laboratory, Wright-Patterson AFB, OH
Computational Electromagnetics and Acoustics		
Automatic Target Recognition and Scene Generation	Dr. Jeff Hughes	Air Force Research Laboratory, Wright-Patterson AFB, OH
A Scalable, Dynamically Adaptive Mesh Software Package for General Magnetohydrodynamic and Space Weather Modeling	Dr. Sprio Antiochos	Naval Research Laboratory, Washington, DC
MACH3: Portable, Scalable, Parallel-Computing Magnetohydrodynamics Software for Multi-materials in Complex 3-D Geometry	Dr. Robert Peterkin	Air Force Research Laboratory, Directed Energy Directorate, Kirtland AFB, NM
Software Development for Electromagnetic Sensing of Surface and Subsurface Targets: Simulation and Signal Processing	Dr. Ronald Chase	Army Research Laboratory, Adelphi, MD

TABLE 5—CONTINUED. COMMON HPC SOFTWARE SUPPORT INITIATIVE PROJECTS AND PRINCIPAL INVESTIGATORS (FISCAL YEAR 2000)

Project	Principal Investigator	Organization
Climate, Weather, and Ocean Modeling and Simulation		
Development of Two Complete Numerical Weather Prediction Systems for Heterogeneous Scalable Computing Environments	Dr. Thomas Rosmond	Naval Research Laboratory, Monterey, CA
Satellite Radiance Variational Data Assimilation: Code Migration to Scalable Architectures	Dr. Frank Ruggiero	Air Force Research Laboratory, Space Vehicles Directorate, Hanscom AFB, MA
Scalable Ocean Models with Data Assimilation	Dr. Alan Wallcraft	Naval Research Laboratory, John C. Stennis Space Center
Scalable Weather Research and Forecast (WRF) Model Development	Major Michael Farrar	Air Force Weather Agency, Offutt AFB, NE
Signal/Image Processing		
Efficient, Maintainable, Portable, and Scalable HPC Codes for Image Fusion and Signal/Image Processing	Dr. Richard Linderman	Air Force Research Laboratory, Information Directorate, Rome, NY
Infrared Search and Track Processing for Missile Surveillance	Mr. Dennis Cattel	Space and Naval Warfare Systems Center, San Diego, CA
Scalable Algorithms for Sonar Beamforming	Mr. Bob Bernecky	Naval Undersea Warfare Center, Newport, RI
Acoustic Analysis Workbench Using Windows NT	Dr. Keith Bromley	Space and Naval Warfare Systems Center, San Diego, CA
Forces Modeling and Simulation/C4I		
Simulation and Analysis of Heterogeneous, Large Scale Communication Networks for Multi-Element Using Commercial-Off-The-Shelf (COTS) and Government-Off-The-Shelf (GOTS) Simulators	Dr. Albert Legaspi	Space and Naval Warfare Systems Center, San Diego, CA
High Level Architecture Runtime Infrastructure	Mr. Jeff Wallace	Space and Naval Warfare Systems Center, San Diego, CA
Environmental Quality Modeling and Simulation		
Structured-Unstructured Modeling	Dr. Robert Bernard	Engineer Research and Development Center, Vicksburg, MS
Resolved Transport Algorithm	Dr. Mark Dortch	Engineer Research and Development Center, Vicksburg, MS
Scalable Parallel Implementation of Department of Defense Groundwater Modeling System	Dr. Fred Tracy	Engineer Research and Development Center, Vicksburg, MS
Computational Electronics and Nanoelectronics		
Efficient Numerical Solutions to Large Scale Military Tactical Communications Problems via a Scalable Time Domain Method (Sc-MRTD)	Dr. Barry Perlman	Army Communications-Electronics Command, Ft. Monmouth, NJ
Integrated Modeling and Test Environments		
Simulation and Software Implementation of Non-Uniformity Correction (NUC) for Multi-Element Infrared Scene Projector (IRSP) Arrays	Mr. Kenneth Lasueur	Redstone Technical Test Center, Redstone Arsenal, AL
Model-Based Test Data Validation	Mr. Joseph Babilon	Arnold Engineering Development Center, Arnold AFB, TN
Real-Time Image-Based Sorting and Classifying on Multiple Parallel Processors	Dr. David Marlin	White Sands Missile Range, NM
High Performance Computing in Concurrent Engineering, Modeling, and Testing	Dr. Andrew Mark	Army Research Laboratory, Aberdeen Proving Ground, MD

HPC CONTRIBUTIONS TO DoD Mission Success — 2000

INTRODUCTION

High performance computing enables detailed computer-based design, virtual prototyping, and improved numerical modeling in order to significantly shorten the acquisition cycle, reduce costs, and increase the effectiveness of DoD weapons systems. High-end computational capabilities impact all aspects of DoD research, development, test, and evaluation — from basic research in the laboratories to testing at the test centers. The extent of this impact is accelerating. When compared with traditional theoretical and experimental methods, computational modeling and simulation allow the exploration of more options at significantly reduced cost. The use of high performance computing, coupled with judiciously chosen experimental data points, provides a powerful tool for improving the development process of DoD warfighting and support systems.

Many major accomplishments have already resulted from the use of high-end computing in the DoD science and technology and test and evaluation programs. In 1995, 1996, 1997, and 1998, the High Performance Computing Modernization Program (HPCMP) published *High Performance Computing Contributions to DoD Mission Success*. Those publications described an extensive array of success stories resulting from the use of HPCMP assets. The HPCMP will publish another *High Performance Computing Technical Report Series* in 2000. Included here are four typical examples from the hundreds of projects being accomplished on HPC provided resources. Applicable references pertaining to these stories can be found at the back of this plan.

- Expanding Diagnostic Capabilities in Aerodynamic Designs
- High Performance Computing Makes Ground Vehicle Simulations Possible
- High Performance Aircraft, High Performance Solutions
- From the Sea to the Shore: Forecasting Surface Wave Conditions for the Military Crisis in Kosovo

EXPANDING DIAGNOSTIC CAPABILITIES IN AERODYNAMIC DESIGNS

R. L. Meakin

Army Aeroflightdynamics Directorate (AMCOM), Moffet Field, CA

As the Department of Defense implements its "Revolution in Military Affairs" it is also conducting a revolution in business affairs, exploiting information systems technology advances that are having a direct impact on the range of acquisition lifecycle activities. High fidelity modeling and simulation increasingly supports testing of advanced weapons systems, which historically relied on techniques such as live testing and wind tunnel testing. Applying high performance computing resources to modeling of aerodynamic designs dramatically expands the diagnostic capabilities available to the Department's scientific and engineering communities, and enables them to quickly identify design weaknesses, at relatively low cost, without endangering human life.

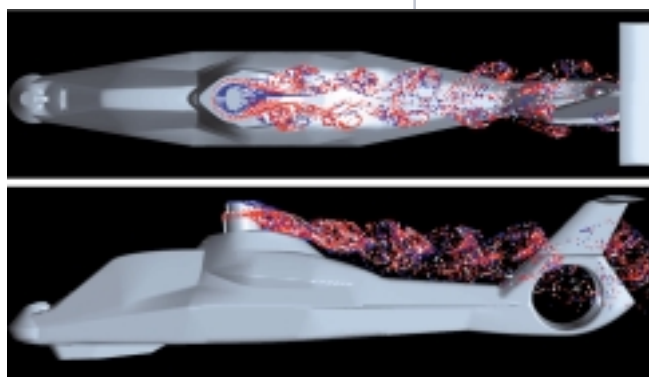
The Army's RAH-66 Comanche helicopter exhibited a tail-buffet phenomenon in level forward flight during flight and in scale-model wind tunnel tests. Dr. Robert Meakin of the U.S. Army Aeroflightdynamics Directorate (AMRDEC), Moffett Field, CA, studied the effects of the tail-buffet on the Comanche. He applied a

High Performance Computing Modernization Program Common HPC Software Support Initiative software application to study the design of the fuselage and rotor hub sections of the aircraft. This application was run on an Engineering Research and Development Center (Vicksburg, MS) IBM-SP supercomputer. By structuring grids in the shape of the Comanche, Dr. Meakin developed a numerical model of the helicopter fuselage and simulated the airflow around it to identify the cause of the problem.

His research showed that the airflow surrounding the rotor hub is forced towards the tail section of the aircraft (see figures below). The buffeting adversely affects the control and handling characteristics of the aircraft and over time, and can lead to structural fatigue of the tail section. Based on Dr. Meakin's high-

resolution simulation methodology, which supplemented wind tunnel and flight test data, design modifications were made to the Comanche.

Dr. Meakin's approach represents a low-risk and relatively quick means of investigating design problems on aircraft and other vehicles susceptible to unsteady flow. Wind-tunnel tests are costly and take time to schedule and run. High fidelity simulations are possible on high performance computing systems. These simulations allow for "what if" design tradeoff studies that are not practical to set up and run in wind tunnels and they allow many more "simulations" in the same amount of time. Today's supercomputers and computational software methods make these types of simulations possible.



Unsteady flow over an isolated Comanche helicopter fuselage (top and side views). Particles released from the base of the rotor hub reveal vortex shedding and downstream convection to the vehicle tail section.

High PERFORMANCE COMPUTING MAKES GROUND VEHICLE SIMULATIONS Possible

M. Brudnak, P. Nunez, and R. Romano

Tank-Automotive Research, Development and Engineering Center (TARDEC), Warren, MI and Realtime Technologies, Inc

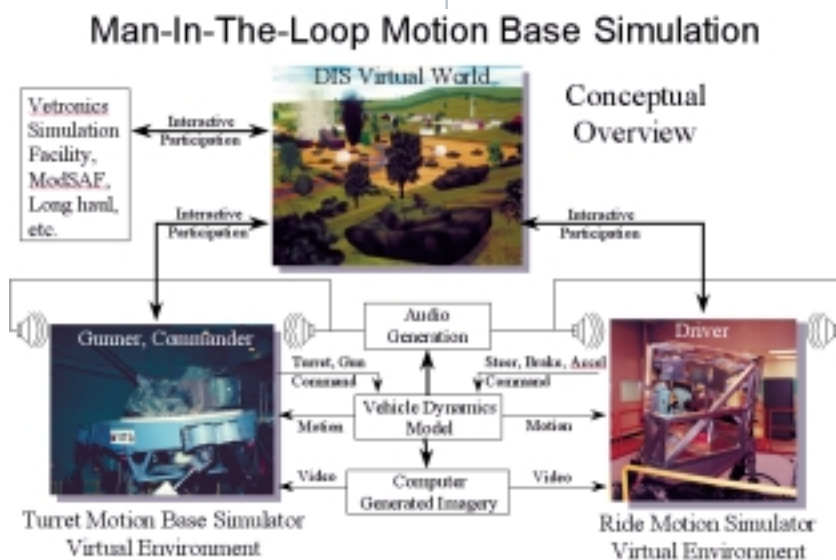
Military ground vehicles play a pivotal role on the modern battlefield. Vehicles such as the BMP-2 armored infantry fighting vehicle and the M1 Abrams tank are essential to conducting a land battle. However, developing military ground vehicles is time consuming and costly. Using high performance computing resources to conduct simulations shortens the design-build-test-modify cycle. High performance computing provides the size, processing speed, and throughput necessary to run these simulations. The Department of Defense (DoD), in association with

industry, has developed the means and technology needed to support simulation research.

The US Army Tank-Automotive Research, Development and Engineering Center (TARDEC) Distributed Center, in Warren, Michigan, built a ground vehicle model and hardware/operator-in-the-loop simulation capability. This capability assesses the performance of a ground vehicle, evaluates design modifications, and helps investigate soldier/machine interfaces. The figure below shows the configuration of the simulation. The TARDEC

Simulation Laboratory is also developing and integrating advances in multi-body dynamics compositions, vehicle-terrain interaction, and synthetic environments to create simulations for engineering design analysis.

Engineers at the TARDEC Simulation Laboratory have successfully integrated a real-time operator-in-the-loop Bradley tank model using the in-house Symbolically Optimized Vehicle Analysis System multi-body dynamics method. The TARDEC team also integrated an Abrams model using technology developed through the National Automotive Center (NAC) sponsored Automotive Research Center. The NAC serves as the Army's focal point for the development of dual-needs/dual-use automotive technologies and their application to military ground vehicles. The Automotive Research Center, a collaboration of government, industry, and academia, develops simulator technologies.



Conceptual overview of TARDEC's Operator-in-the-loop distributed simulation

The TARDEC engineers used their SGI Power Challenge Array and the Origin 2000 to run the Bradley and Abrams tank models in a distributed computational environment. The models provide motion cues to the Ride Motion Simulator. When the simulator is used with the current Crew Station/Turret Motion Base Simulator, the soldier can drive or operate the vehicle, and respond to battlefield scenarios run either locally or networked to the Defense Simulation

Internet. The TARDEC team can create an entire synthetic environment including high frequency motion cues, high-resolution terrain, and realistic video and audio responses. These engineering-high fidelity models run at real-time update rates on the SGI Origin 2000 supercomputer provided by the DoD High Performance Computing Modernization Program.

Using high performance computing resources, the US Army includes the soldier early in the design cycle to evaluate vehicle designs and modifications without investing heavily in the production of hardware. This greatly reduces the design-build-test-modify cycle. It also significantly increases readiness by producing systems that are more effective in a shorter period with less cost than was previously possible.

High PERFORMANCE AIRCRAFT, High PERFORMANCE SOLUTIONS

E.A. Jarvis and E.A. Carter

University of California at Los Angeles, Los Angeles, CA

Materials science is a cornerstone of weapons systems design within the Department of Defense. The challenge has always been, and continues to be, our ability to have greater granularity in the exploration of new chemicals and compounds that will form the basis for national defense in the 21st century. This is particularly true in the development of high performance aircraft.

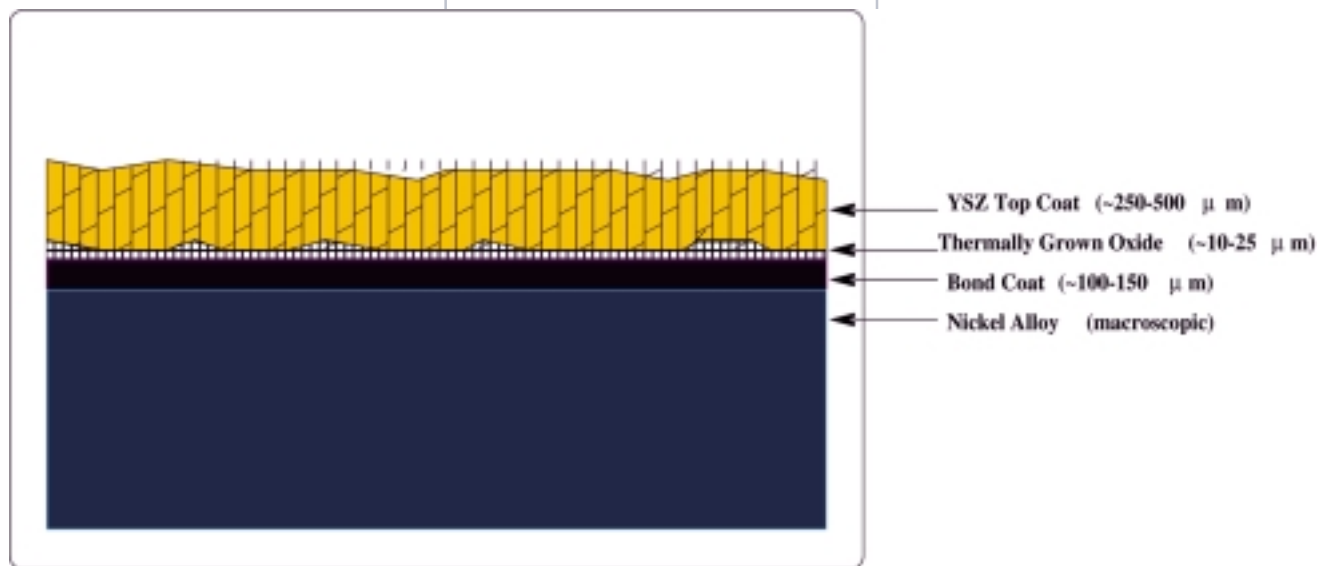
In order to achieve maximum power and fuel efficiency, aircraft engines must operate at high temperatures, often above the melting range of the engine metal alloy. To gain maximum power and fuel efficiency, Thermal Barrier

Coatings (TBCs) must be used to protect the underlying metal superalloys (which are high-strength complex alloys resistant to high temperature) from melting. TBCs consist of a thin ceramic layer with a metal alloy bond-coat layer between the ceramic and the underlying engine superalloy. With repeated thermal cycling, these coatings tend to crack and chip.

Under contract by the Air Force, two researchers, E.A. Jarvis and E.A. Carter, from the University of California at Los Angeles are modeling surfaces and interfaces present in a TBC system using high performance computing resources provided

by the High Performance Computing Modernization Program. They were able to develop a new atomic-level understanding of the causes of chipping with increasing Thermally Grown Oxide (TGO) thickness. (The TGO is a “layer” which grows between the ceramic topcoat and the metal alloy bond coat that results from high temperature oxygen ion diffusion through the ceramic topcoat. This TGO region introduces strain on the system.) The build up of a TGO region may cause TBC failure.

The team used Density Functional Theory to obtain properties of the system by solving for the electron



Schematic cross-section of a thermal barrier coating

density. The periodic boundary conditions allow simulation of “infinite” surfaces. The computational work concentrates on the valence or “outer” electrons. The results will help the

Department improve the bond coat layer by decreasing thermal expansion mismatch strain while promoting adhesion of the TBC to the engine alloy. This work could

lead to higher performance jet engines with longer operating cycles between maintenance actions. That means more capable aircraft with lower maintenance costs.

FROM THE SEA TO THE SHORE: FORECASTING SURFACE WAVE CONDITIONS FOR THE MILITARY CRISIS IN KOSOVO

M. Brooking, J. Dykes, G. Mason, P. Wilz, R. Allard, and R. Jensen

Warfighting Support Center, Naval Oceanographic Office (NAVO), Planning Systems Inc., and Naval Research Laboratory (NRL), at Stennis Space Center, MS, and Engineer Research and Development Center (ERDC), Vicksburg, MS

Environmental conditions directly impact the success of military missions around the world. In particular, the Navy relies heavily on environmental forecasting during the conduct of amphibious landings. Recently, events in Kosovo prompted the Navy to rapidly apply the high performance computing capabilities of the Naval Oceanographic Office (NAVOCEANO) with those of the Naval Research Laboratory – Stennis Space Center (NRL-SSC) to rapidly coordinate the configuration of a prototype numerical model capable of predicting wave products from the deep water of the Adriatic Sea to the shallow waters of coastal Albania. The timely delivery of tactically significant information to the fleet was

possible only with high performance computing resources provided by the HPCMP.

In response to military needs, NAVOCEANO provided a 72-hour wave height and direction forecast at a 5-minute resolution for the Adriatic Sea. As the military situation matured and the likelihood of an amphibious landing increased, the information available from the 5-minute resolution Wave Model (WAM) was insufficient for near-shore operations. Figure 1 shows a typical WAM product delivered during the Kosovo crises. Fortunately, NAVOCEANO had been developing the Steady State Spectral Wave Model (STWAVE) at the NAVO Major Shared Resource Center

(MSRC) and had the program configured to support final operational evaluation. The operational need in Kosovo led the Navy to rapidly commission the STWAVE as a predictive model before it had completed final Operational Evaluation.

STWAVE provided wave prediction information in the shallow water zone between 2 to 20 meters that allowed for detailed planning of amphibious operations. Figure 2 shows a typical STWAVE product delivered during the Kosovo crises. Because of the HPCMP high performance computational resources available at the NAVO MSRC, the wave-forecast results were provided to the fleet in a timely manner.

Figure 1. WAM product delivered during the Kosovo Crisis

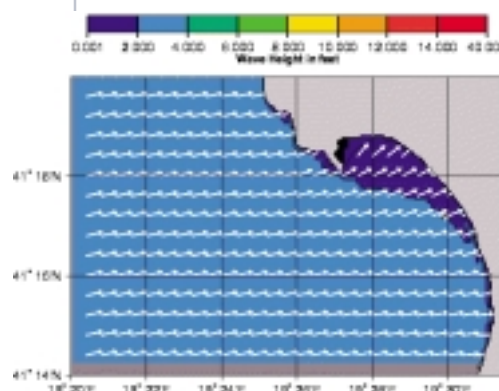
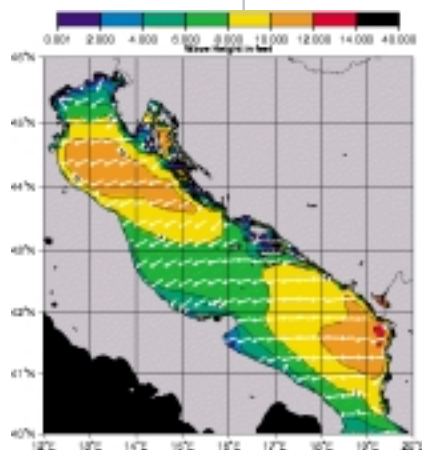


Figure 2. STWAVE product delivered during the Kosovo Crisis

PROGRAM ACCOMPLISHMENTS AND FUTURE PLANS

High Performance Computing Centers

Major Shared Resource Centers

The High Performance Computing Modernization Program (HPCMP) completed key acquisitions to establish four major shared resource centers (MSRCs) in fiscal year 1996. Integration contracts provide the centers' hardware, software, maintenance, operations, and support staff. Each contract includes a base computational capability (referred to as Performance Level I) with two options to upgrade the capability as funds become available (referred to as Performance Levels II and III). Since the first high performance computing systems were fielded by the program in 1993, the total peak computational high performance computing capability at the MSRCs increased from 30 gigaflops to just over 3,481 gigaflops at the end of fiscal year 1999. During fiscal year 2000, the program will continue to modernize the centers to sustain the Defense Department's world-class high performance computing infrastructure. Approximately 2,800 peak gigaflops are expected to be added during fiscal year 2000, for a total of 6.2 teraflops. (It should be noted that "Peak Teraflops" represent a simple measure of growth. It, however, does not consider architecture specific features, nor does it provide a measure of actual performance delivered). Table 6 shows the fiscal year 2000 high performance computing systems' capability planned for the MSRCs.

Major Shared Resource Centers, Fiscal Year 2000

In fiscal year 2000, the program will sustain the centers' high performance computing capabilities, completing the Performance Level III upgrade that began in fiscal year 1999. When concluded, the upgrade will have increased each center's capability at least tenfold over that in fiscal year 1996. The program will continue to provide improved operating environments, supporting tools, and software in the users' ten computational technology areas. The multi-year process of building the centers' wide area computing environment will continue as well, with an emphasis on peripheral and archival

High Performance Computing Centers— CONTINUED

mass storage capabilities. The program will continue to provide user training and interaction with other government agencies, industry, and academic centers so that defense scientists and engineers can take advantage of the latest high performance computing expertise, capabilities, standards, and infrastructure.

**TABLE 6. MAJOR SHARED RESOURCE CENTERS High Performance Computing Capability
(FISCAL YEAR 2000)**

Major Shared Resource Center	Processors	Total Memory (gigabytes)	Total Capability (gigaflops)
Aeronautical Systems Center (ASC), Wright-Patterson AFB, OH			
IBM SP/SMP Power 3	264	264	211
SGI Origin 2000/195	128	128	51
SGI Origin 2000/195	384	192	154
IBM SP/135	256	264	126
Compaq ES-40, EV-6	64	64	64
Army Research Laboratory (ARL), Aberdeen Proving Ground, MD			
Cray SV1	32	28	38
SGI Origin 2000/300	256	256	153
SGI Origin 2000/250	32	32	16
SGI Origin 2000/250 (Classified)	128	112	64
SGI Origin 2000/250 (Classified)	64	32	32
SGI Origin 2000/300 (Classified)	32	28	13
SGI Origin 2000/195 (Classified)	32	32	19
Sun E10000	128	128	102
Sun E10000 (Classified)	128	128	102
Cray SV1 (Classified)	16	32	19
Engineer Research and Development Center (ERDC), Vicksburg, MS			
Cray T3E-1200	544	136	653
IBM SMP Power 3	512	256	455
IBM SP/135	256	256	138
IBM SP/160	126	63	81
SGI Origin 2000/195	128	64	50
Naval Oceanographic Office (NAVO), Stennis Space Center, MS			
Cray T3E-900	1,088	400	979
SGI Origin 2000/195+250	256	128	114
Cray SV1-2	32	32	38
Cray T90	16	8	29
Cray J916SE (Classified)	16	4	3
SGI Origin 2000/250 (Classified)	8	4	4
Sun E10000 32-way SMP	32	32	26

Note: Current as of July 2000.

High Performance Computing Centers— CONTINUED

Major Shared Resource Centers, Fiscal Year 2001

The program will continue the upgrade of major shared resource center capabilities in response to increasing user requirements. Additional high performance computing systems, mass storage, and scientific visualization capabilities will be added to the centers. The multi-year process of building the major shared resource centers' wide area computing environment will continue, with an emphasis on wide-area sharing of storage resources. Programming environment and training activities will continue to emphasize distance learning and distributed training, ensuring that defense scientists and engineers can take advantage of expanded high performance computing capabilities as they become available.

Distributed Centers

Since fiscal year 1993, the program has established and upgraded the computational capabilities of distributed centers (DCs). Distributed centers are selected annually for a one-time investment in high performance computing equipment. Typically, the equipment is no longer considered high performance computing class after three to four years. If a DC is not selected for an upgrade in computational capability during this time period, the center may be retired as an HPCMP DC under the program's sunset policy. In February 1999, four existing and two new DCs were selected to receive a total of \$18 million for the procurement of high performance computing systems as part of the fiscal year 1999 distributed center selection process. In April 1999, the office conducted a post-deployment evaluation and assessment of DCs selected in fiscal year 1997 and reviewed their progress towards meeting stated goals and milestones.

Distributed Centers, Fiscal Year 2000

Table 7 lists the program's fiscal year 2000 DCs. Table 8 shows the fiscal year 2000 high performance computing systems at the DCs. The total peak gigaflop computational capability at the distributed centers is expected to reach just over 4,500 gigaflops at the end of fiscal year 2000.

In December 1999, six organizations were selected to receive a total investment of \$19M for the procurement of high performance computing systems. The six centers receiving awards were: the Redstone Technical Test Center (Huntsville, AL); the Naval Air Warfare Center, Aircraft Division

High Performance Computing Centers— CONTINUED

(Patuxent River, MD); the Naval Research Laboratory (Washington, DC); the Air Force Flight Test Center (Edwards AFB, CA); the Air Force Research Laboratory, Sensors Directorate (Wright-Patterson AFB, OH); and the Maui High Performance Computing Center (Kihei, HI). These centers will acquire high performance computing systems during fiscal year 2000.

The Redstone Technical Test Center will use its high performance computing assets to expand and refine the capability of its Dynamic Infrared Scene Projector. The Naval Air Warfare Center, Aircraft Division will expand the computational power of its modeling and simulation capability

TABLE 7. Distributed Centers

Center	Location	Most Recent Upgrade
Air Armament Center (AAC)	Eglin AFB, FL	1999
Air Force Flight Test Center (AFFTC)	Edwards AFB, CA	2000
Air Force Research Laboratory Information Directorate (AFRL/IF)	Rome, NY	1998
Air Force Research Laboratory Sensors Directorate (AFRL/SN)	Wright-Patterson AFB, OH	2000
Arctic Region Supercomputing Center (ARSC)	Fairbanks, AK	1999
Army High Performance Computing Research Center (AHPCRC)	Minneapolis, MN	2000
Arnold Engineering Development Center (AEDC)	Arnold AFB, TN	1999
Joint National Test Facility (JNTF)	Schriever AFB, CO	1999
Maui High Performance Computing Center (MHPCC)	Kihei, HI	2000
Naval Air Warfare Center Aircraft Division (NAWCAD)	Patuxent River, MD	2000
Naval Air Warfare Center Weapons Division (NAWCWD)	China Lake, CA	1999
Naval Research Laboratory (NRL-DC)	Washington, DC	2000
Redstone Technical Test Center (RTTC)	Huntsville, AL	2000
Space and Missile Defense Command (SMDC)	Huntsville, AL	1996
Space and Naval Warfare Systems Center (SSC-SD)	San Diego, CA	1999
Tank Automotive Research, Development and Engineering Center (TARDEC)	Warren, MI	1999
White Sands Missile Range (WSMR)	White Sands Missile Range, NM	1998

**TABLE 8. Distributed Centers High Performance Computing Capability
(Fiscal Year 2000)**

Distributed Centers	Processors	Total Memory (gigabytes)	Total Capability (gigaflops)
Air Armament Center (AAC), Eglin AFB, FL			
SGI Origin 2000	20	20	10
SGI Onyx (Classified)	32	8	13
Air Force Research Laboratory Information Directorate (AFRL/IF), Rome, NY			
Sky Excalibur	384	25	256
Arctic Region Supercomputing Center (ARSC), Fairbanks, AK			
Cray J932	12	8	2
Cray T3E	272	68	230
Army High Performance Computing Research Center (AHPCRC), Minneapolis, MN			
Cray T3E	1,296	259	1,303
Arnold Engineering Development Center (AEDC), Arnold AFB, TN			
HP V2500	64	64	113
HP V2500 (Classified)	64	32	113
SGI Origin 2000	64	32	38
Joint National Test Facility (JNTF), Schriever AFB, Colorado Springs, CO			
SGI Onyx 2 (Classified)	88	44	83
SGI Origin 2000 (Classified)	64	32	64
Maui High Performance Computing Center (MHPCC), Kihei, HI			
IBM P3/SMP (Classified)	320	56	480
IBM SP3/SMP	160	80	142
IBM P2SC	160	80	102
IBM SP2 (Classified)	128	40	34
IBM P2SC (Classified)	32	8	15
IBM P2SC	32	20	21
IBM SP2 (Classified)	48	13	13
IBM P3/SMP	16	2	14
IBM P2SC	19	4	9
IBM P2/SMP	64	8	29
IBM P3/SMP	16	8	14
IBM P3/SMP	8	4	7
IBM P2	16	2	4

Note: Current as of July 2000.

**TABLE 8—CONTINUED. DISTRIBUTED CENTERS HIGH PERFORMANCE COMPUTING CAPABILITY
(FISCAL YEAR 2000)**

Distributed Centers	Processors	Total Memory (gigabytes)	Total Capability (gigaflops)
Naval Air Warfare Center Aircraft Division (NAWCAD), Patuxent River, MD			
SGI Power Challenge (Classified)	40	12	16
SGI Onyx 2 (Classified)	64	24	25
Naval Air Warfare Center Weapons Division (NAWCWD), China Lake, CA			
SGI Onyx 2 (Classified)	64	24	25
Naval Research Laboratory (NRL), Washington, DC			
HP Exemplar SPP-2000	80	20	57
SGI Origin 2000	128	128	77
Sun Ultra	140	31	63
Redstone Technical Test Center (RTTC), Redstone Arsenal, AL			
SGI Origin 2000	32	7	13
SGI Origin 2000 (Classified)	32	7	13
Space and Missile Defense Command (SMDC), Huntsville, AL			
SGI Origin 2000	128	32	52
SGI Origin 2000	64	22	26
SGI Origin 2000	64	16	26
SGI Origin 2000	32	8	13
SGI Origin 2000	16	4	6
SGI Origin 2000 (Classified)	8	2	3
SGI Origin 2000 (Classified)	8	2	3
Space and Naval Warfare Systems Center (SSC- SD), San Diego, CA			
HP V2500	16	24	28
HP V2500 (Classified)	16	24	28
Tank-Automotive Research, Development and Engineering Center (TARDEC), Warren, MI			
SGI Power Challenge	60	12	22
SGI Onyx 2	32	31	16
White Sands Missile Range (WSMR), NM			
SGI Origin 2000	128	48	75

Note: Current as of July 2000.

High Performance Computing Centers— CONTINUED

at the site's Air Combat Environment Test and Evaluation Facility. The Naval Research Laboratory continues to serve as the DoD high performance computing community's pathfinder, exploring, maturing, and stabilizing "leading edge" technological advancements prior to their introduction to the wider DoD high performance computing user community. The Air Force Flight Test Center intends to use high performance computing to develop high fidelity models to simulate electronic warfare battlefields. The Air Force Research Laboratory Sensors Directorate's research in the areas of signal and image processing (SIP) and automatic target recognition (ATR) will be greatly enhanced with a state-of-the-art rugged and mobile high performance computing system. Finally, the Maui High Performance Computing Center will update and expand high performance computing assets for users requiring classified computing resources.

Also, in Fiscal Year 2000, Congress provided additional funding to the program to significantly expand the high performance computing capability at the Army High Performance Computing Research Center Distributed Center. The AHPCRC system configuration shown at Table 8 is a result of that funding. The system increased by almost 1, 000 processors and almost 1,000 gigaflops - making the center's Cray T3E, one of the largest in the world.

DISTRIBUTED CENTERS, FISCAL YEAR 2001

There currently is no call for proposals planned in fiscal year 2001 due to funding constraints.

NETWORKING

DEFENSE RESEARCH AND ENGINEERING NETWORK

During 1998, the Defense Research and Engineering Network (DREN) completed its transition from an interim, point-to-point T-3 (45 million bits per second) backbone to an OC-3c (155 million bits per second) virtual private network over a public commercial asynchronous transfer mode (ATM) communications infrastructure. DREN has added another major Network Access Point (NAP) at Chicago, IL in order to exchange wide area network traffic more efficiently with other congressionally funded initiatives such as Next Generation Internet (NGI) and the Internet 2 ABILENE project. DREN also participates in Next Generation Internet EXchanges (NGIXs) and in other Metropolitan Area Exchanges (MAEs).

NETWORKING—CONTINUED

DREN is a major participant in enhancing wide area networking between Alaska and Hawaii and the continental United States.

The HPCMP co-chairs the Joint Engineering Taskforce (JET). The JET, which replaced the Federal Networking Council, is chartered by the National Science and Technology Council's Subcommittee on Computing Information and Communications. The JET acts as a forum for network engineering collaborations between federal agencies to meet their research, education, and operational mission goals. The JET also works to bridge the gap between advanced networking technologies being developed and the eventual acquisition of mature versions of these technologies from the commercial sector for the Federal market.

DREN, FISCAL YEAR 2000

During fiscal year 2000, network connectivity will be sustained, and options to increase the bandwidth for the major shared resource centers and other selected sites will be executed. This increased bandwidth will facilitate participation in distributed computing environment testbeds. The DREN plans to continue adding sites to its high-speed classified virtual private network and will work towards establishing mutual peering with other classified networks. In collaboration with the Defense Information Systems Agency (DISA), acquisition planning continues to ensure that DREN services are available in the future. The program will continue ongoing efforts to enhance the total bandwidth capability.

DREN, FISCAL YEAR 2001

During fiscal year 2001, network connectivity will be sustained and additional options for increased bandwidth will again be executed. DREN will continue to support the testbed environments and facilitate the distributed computing environments across the program's MSRCs and selected DCs. The long term objective of this effort is to optimize sharing of valuable Department of Defense (DoD) HPC resources across centers by supporting dynamic, real-time, ubiquitous computing environments; providing better protection during times of disaster or extended outages; and by eliminating single points of failure. The very high-speed DREN will be the key to success, since individual centers will need immediate, bandwidth-intensive connectivity to move increasingly larger data sets.

Networking—Continued**Security**

Security at HPCMP sites and on the DREN continues to be improved. During 1999, the HPCMP implemented the Uniform Use-Access Policy for Unclassified DoD HPCMP Resources to ensure that security requirements for obtaining accounts at all HPC centers are adequate to protect HPC resources. The program also instituted independent National Security Agency Security Assessments at MSRCs and selected DCs. These assessments provide an independent review and verification of the sites' security postures. Centralized network intrusion detection systems (NIDS) coverage has been expanded to all HPC centers and is being implemented at access points where the DREN meets the Internet and other networks. The HPC Computer Emergency Response Team (CERT) is in place to support all HPCMP users. The HPCMP entered into a joint project with the Department of Energy (DOE) to improve the DOE-owned Joint Intrusion Detection (JID) software used on our NIDS. HPCMP researchers at Army Research Laboratory (ARL) modified the JID software so that it can monitor high-speed ATM network traffic. The code improvement increases the number of locations where intrusion detection can be performed and allows the program to monitor all DREN traffic. The DOE will distribute the improved code to agencies across the government. The HPCMP has also increased the level of security filtering done across the DREN. In concert with the Services and DISA, access control lists (ACLs) on devices at network access points have been expanded to provide increased protection from known sources of attack. HPCMP ACLs are coordinated with the Services and DISA lists to ensure coverage that meets all DoD requirements.

Security, Fiscal Year 2000

Our defense-in-depth strategy is protecting the program in the face of increasing numbers of cyber space attacks. The HPCMP has concentrated its security efforts, including certification and accreditation (C&A), at the edges of the network on the host systems. During fiscal year 2000, the HPCMP will add to its security posture by rewriting its system security authorization agreements and by performing a C&A of the DREN. To increase the speed with which attacks on HPCMP resources are identified, the HPCMP will evaluate and prepare plans to field real-time monitoring solutions, which augment existing capabilities. The joint project with DOE to

NETWORKING—CONTINUED

improve the JID software will also continue in fiscal year 2000. HPCMP researchers and contractors will improve the code so that it effectively uses multiprocessor computers and is capable of monitoring at speeds up to OC-12.

COMMON HIGH PERFORMANCE COMPUTING SOFTWARE SUPPORT INITIATIVE

Several Common High Performance Computing Software Support Initiative (CHSSI) teams released alpha and beta software products in fiscal years 1997 and 1998. Evaluations of these products show a significant improvement in capability to efficiently exploit HPC scalable systems in support of a large number of DoD user projects, including DoD Challenge Projects. Several of these products are used in important defense applications such as armor-anti-armor simulations, blast-structure interactions, antenna design, and radar cross section calculations for aircraft and ground vehicles. Many products incorporate state-of-the-art user interface and graphic capabilities that increase usability and improve analyses by users. The program office promulgated a call for proposals to DoD laboratories and test centers in fiscal year 1999. Numerous proposals were solicited and evaluated. Sixteen new CHSSI projects were selected for initiation at the start of fiscal year 2000.

SOFTWARE SUPPORT, FISCAL YEAR 2000

The initiative will continue to develop, test, and release software in fiscal year 2000 to take advantage of advances in high-speed computing and communications technology, especially in distributed computing, wide-area computing environments, massively parallel high performance computing architectures, and remote desktop collaboration. During fiscal year 1999, the initiative increased its emphasis on strong software engineering, reusability, and maintainability. Additional projects will be initiated as ongoing projects are completed.

SOFTWARE SUPPORT, FISCAL YEAR 2001

Software development, testing, and deployment will continue in fiscal year 2001. Many of the original CHSSI projects will reach completion. The HPCMO will solicit and evaluate proposals for new projects. These new projects will allow the DoD to develop and transition additional key DoD applications software to work effectively on new scalable architectures.

DoD High Performance Computing Challenge Projects

Approximately 25 percent of the program's total computational resources are allocated annually to high-priority Service and Agency projects with very large computational requirements. These mission-critical, computationally intensive DoD Challenge Projects are approved by the Deputy Undersecretary of Defense (Science and Technology) (DUSD(S&T)). Proposals are evaluated by the DoD Challenge Projects Allocation Board with representatives from each Service, selected Defense Agencies, and the broader HPC community. The Board selected 34 projects for implementation in fiscal year 2000. Many of the projects use multiple hardware platforms and in some cases, multiple HPC centers. Computationally, these projects were allocated an average of 46 gigaflops-years for the period October 1999 through September 2000. Table 9 lists the fiscal year 2000 DoD HPC Challenge Projects. A new set of DoD HPC Challenge Projects will be selected during fiscal year 2000 for implementation in fiscal year 2001, continuing the annual selection and evaluation process.

Program Oversight and Review

During fiscal year 1998, the HPCMP performed the Initial Operational Test and Evaluation of its systems in compliance with federal statutes and Defense Department regulations. The Joint Interoperability Test Command (JITC) served as the independent test activity and performed the initial operational evaluation of the program. The command witnessed the evaluation of two MSRCs, two DCs, and two CHSSI code development projects as well as site acceptance testing of the DREN.

In January 1999, the JITC issued an Independent Evaluation Report stating the HPC centers and network are operationally effective and operationally suitable. The report stated,

*"The HPCMP is operationally effective and suitable when operated by its intended users in its operational environment. **Users generally agreed the HPCMP has revolutionized their ability to conduct scientific and engineering research.** [emphasis added] They indicated that problems, while needing attention, are minor to the HPCMP's overall contribution to their research efforts."*

TABLE 9. DoD High Performance Computing Challenge Projects (Fiscal Year 2000)

Project	Sponsoring Organization	Systems
Computational Structural Mechanics		
Damage Simulations in Hard and Deeply Buried Targets Due to Internal Blast and Shock Loading	Engineer Research and Development Center	IBM SP Cray T3E SGI Origin 2000
Development of Standards for Stand-Off Distance and Blast Walls for Force Protection	Engineer Research and Development Center	IBM SP Cray T3E SGI Origin 2000
Modeling Complex Projectile Target Interactions	Army Research Laboratory	SGI Origin 2000 Cray J90 Sun E10000
Computational Fluid Dynamics		
3-D Computational Fluid Dynamics (CFD) Modeling of the Chemical Oxygen-Iodine Laser (COIL)	Air Force Research Laboratory	SGI Origin 2000 Cray T3E
Analysis of Infrared Radiance Effects from DivertJet Exhaust Flow Over the Theater High Altitude Area Defense (THAAD) Seeker Window	Space and Missile Defense Command	Cray T90 SGI Origin 2000
Applied CFD in Support of Aircraft-Store Compatibility and Weapons Integration	Air Armament Center	SGI Origin 2000
Automatic Aerodynamic Design for Complete Aircraft Configurations Using an Adjoint Based Multiblock Method	Air Force Office of Scientific Research	SGI Origin 2000
Contaminant Transport and Source Simulations for Urban and Environmental Hazard Assessment	Naval Research Laboratory	Convex Exemplar IBM SP SPP-2000 SGI Origin 2000
High-Resolution Adaptive Mesh Refinement (AMR) Simulation of Confined Explosions	Defense Threat Reduction Agency	Cray T3E IBM SMP IBM SP
Hybrid Particle Simulations of High Altitude Nuclear Explosions in 3D	Defense Threat Reduction Agency	SGI Origin 2000
Integrated High Performance Turbine Engine Technology (IHPTET) Combustor Design Studies Using Large-Eddy Simulation (LES)	Air Force Research Laboratory	Cray T3E SGI Origin 2000
Interdisciplinary Advanced Aerospace Vehicle Simulation	Air Force Research Laboratory	IBM SP Cray T3E SGI Origin 2000
Numerical Modeling of Wake Turbulence for Naval Applications: Vortex Dynamics and Late-Wake Turbulence in Stratification and Shear	Office of Naval Research	Cray T3E SGI Origin 2000
Parallel Simulations of Flow-Structure Interactions	Office of Naval Research	IBM SP Cray T3E
Parallel Simulations of Reacting Turbulent Two-Phase Flows	Army Research Office	SGI Origin 2000 Cray T3E
Parallel Simulations of Weapons/Target Interactions Using a Coupled CFD/Computational Structural Dynamics (CSD) Methodology	Defense Threat Reduction Agency	Cray T90 IBM SMP SGI Origin 2000
Time Domain Computational Ship Hydrodynamics	Office of Naval Research	IBM SP SGI Origin 2000 Cray T3E Cray T90

TABLE 9—CONTINUED. DoD High Performance Computing Challenge Projects (Fiscal Year 2000)

Project	Sponsoring Organization	Systems
Computational Fluid Dynamics (Cont.)		
Unsteady Aerodynamics of Advanced Guided Munitions	Army Research Laboratory	SGI Origin 2000 IBM SP
Unsteady Aerodynamics of Aircraft Maneuvering at High Angles of Attack	Air Force Research Laboratory	IBM SP Cray T3E
Unsteady Hydrodynamics of the Maneuvering Submarine	Office of Naval Research	SGI Origin 2000 Cray T3E
Computational Chemistry and Materials Science		
Computationally Assisted Development of High Temperature Structural Materials	Air Force Research Laboratory	IBM SP Cray T3E SGI Origin 2000
Computer Design of Materials from First Principles Theory: A Supercomputer-Based Laboratory	Naval Research Laboratory	IBM SP IBM SMP
Multiscale Simulation of Nanotubes and Quantum Structures	Office of Naval Research	Cray T3E
New Materials Design	Air Force Research Laboratory Air Force Office of Scientific Research	Cray T90 SGI Origin 2000 IBM SP
Theoretical Investigation of Gun Tube Erosion Related Requirement	Army Research Laboratory	SGI PCA SGI Origin 2000
Computational Electromagnetics and Acoustics		
Airborne Laser Challenge Project	Air Force Research Laboratory	Cray T3E IBM SP
Evaluation and Design of Advanced Navy Topside Communications Systems	Space and Naval Warfare Systems Center, San Diego	IBM SP
Virtual Prototyping of Radio Frequency (RF) Weapons	Air Force Research Laboratory	Cray T90 IBM SP SGI Origin 2000
Climate, Weather, and Ocean Modeling and Simulation		
Coupled Environmental Model Prediction (CEMP)	Naval Postgraduate School Naval Research Laboratory	Cray T3E SGI Origin 2000
Data Assimilation in High Resolution Numerical Simulations of the Ocean Circulation	Office of Naval Research	Cray T3E
Global and Basin Scale Ocean Modeling and Prediction	Naval Research Laboratory	Cray T3E
Signal/Image Processing		
Automatic Target Recognition Performance Evaluation	Air Force Research Laboratory	SGI Origin 2000
Environmental Quality Modeling and Simulation		
Quantification of the Impacts of Subsurface Heterogeneity on Military Site Cleanup	Engineer Research and Development Center	IBM SP Cray T3E
Computational Electronics and Nanoelectronics		
Atomistic Simulation of Micro-Electromechanical (MEMS) Devices via the Coupling of Length Scales	Naval Research Laboratory	IBM SP

PROGRAM OVERSIGHT AND REVIEW— CONTINUED

The results of the evaluation represent a significant step for the program in the formal oversight process. The Independent Evaluation Report for CHSSI projects was also favorable. The annual test report to Congress by the Director, Operational Test and Evaluation, contained no significant findings about the program.

Following the test period, acquisition oversight of the program was formally delegated from the Assistant Secretary of Defense (Command, Control, Communications and Intelligence) to the Deputy Undersecretary of Defense (Science and Technology).

In December 1998, the Under Secretary of Defense for Acquisition, Technology, and Logistics USD(AT&L) formed an Integrated Product Team (IPT) under the leadership of the DUSD(S&T). The IPT, after a year of review, reaffirmed the critical impact high performance computing is having on the DoD. Specifically, they concluded HPC is a critical enabling tool that decreases the time to solution, enables new and innovative approaches, and allows the solution of highly complex, previously unsolvable problems. They further noted that the current HPCMP not only leverages common resources for both the science and technology (S&T) and test and evaluation (T&E) communities, it also promotes the transition of technology from S&T to T&E.

During fiscal year 2000, the program will continue an aggressive test program to ensure defense scientists and engineers receive high performance computing assets that are operationally effective and suitable for their work efforts. In April 1999, the HPCMP carried out a post-deployment evaluation of distributed centers selected for implementation in fiscal year 1997. Representatives of the program office will witness testing at selected MSRCs, all DCs selected for implementation in fiscal year 2000, and beta tests under the CHSSI. In March 2000, the program assessed the efficiency and effectiveness of all program initiatives.

Acquisition

Accomplishments

We are entering a new round of acquisitions in the program office. This gives us the opportunity to examine what worked, what needs improvement, and what the current DoD best practices for the program are as a whole. All of the

Acquisition— CONTINUED

program elements that expire in the near term are developing new strategies. These strategies include extending current efforts through contract modifications, using existing contract vehicles, and planning for new procurements. IPTs will assist in the planning and integration of long-term program initiatives and acquisitions.

FUTURE PLANS

Our future plans include developing strategies that make information technology contracting more successful and not just more streamlined. We are actively looking at performance-based contracting, cost as an independent variable, award-term contracting, and share-in-savings concepts.

PROGRAM FUNDING

The HPCMP is projected to spend \$1.24 billion for fiscal years 2000–2005. Table 10 shows the funding profile by year and major spending category, including actual budgets for fiscal years 1997–1999 and the six-year projections from the President’s fiscal year 2000 budget. Within the overall program, the funding level currently supports only a portion of the validated high performance computing requirements (e.g., in fiscal year 1999, the program provided approximately 30 percent of the computing capability needed by the user community). Although there have been a number of budget adjustments since the 1994 modernization plan, most of the reductions for fiscal years 2000–2003 are the result of a single \$269 million reduction sustained by the program as part of the final resolution of the Defense Program Objective Memorandum for fiscal years 1997 through 2001.

The increase in fiscal year 2000 procurement from last year’s modernization plan was provided by Congress in the fiscal year 2000 Department of Defense Appropriations Act. As a result, the program anticipates being able to support 50–60% of the documented requirement in fiscal year 2000.

The modest budget increase in fiscal year 2001 Research, Development, Test, and Evaluation funding from last year’s plan supports sustainment funding for the Arctic Region Supercomputing Center (Fairbanks, AK) and the Maui High Performance Computing Center (Kihei, HI).

PROGRAM FUNDING— CONTINUED

Comparison of the current budget profiles with earlier budget projections, industry briefings, and acquisition documents indicates that over 75 percent of the cumulative reductions referenced above—an average of almost \$100 million per year beginning in fiscal year 2000—will be sustained by the program's acquisition account as a direct result of the \$269 million reduction described earlier. As

TABLE 10. DEPARTMENT OF DEFENSE HIGH PERFORMANCE COMPUTING MODERNIZATION PROGRAM FUNDING (FISCAL YEARS 1997–2005)

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Procurement (Capital Investments)	122.7	87.1	91.4	95.8	40.0	50.4	49.4	50.3	51.9
Research, Development, Test and Evaluation									
Networking (Includes Security)	16.0	21.7	17.0	29.3	32.7	32.9	33.1	33.7	34.6
Common High Performance Computing Software Support Initiative	21.1	20.9	23.6	21.6	22.3	20.7	20.7	21.8	22.3
Major Shared Resource Centers	52.8	72.1	87.6	87.2	88.3	83.6	88.4	89.5	90.9
Distributed Centers	28.5	24.3	23.4	26.2	20.7	0.8	0.8	0.8	0.8
PROGRAM TOTAL	241.1	226.1	243.0	260.1	204.0	188.4	192.4	196.1	200.5

stated in previous modernization plans, the lower budget is sufficient to exercise the base capability as currently programmed for Performance Level III of the contracts for the MSRCs, but severely limits future capital investments.

A significant fraction of the projected user requirements can not be adequately addressed by the current funding profile. Therefore, as part of its strategic planning efforts, the HPCMP staff continues to examine options to ensure that the highest priority warfighter needs are met in light of these shortfalls. An extensive HPC resource allocation process ensures the program's resources are allocated by the Services and Defense Agencies to the highest priority projects of the Defense Department.

Other significant results of the out-year budget reductions include scaling back the growth rate for network capability and phasing out most sustainment funding for the DCs. These reductions will have the greatest impact on new or just emerging applications requiring either real-time or high-end interactive support at sites remote to MSRCs. The continued stable funding of the CHSSI and the MSRC sustainment budget lines reflect the importance that the program places on software, integration, and related shared services to its HPC user community. These investments will continue to guarantee that the program's focus remains on enabling users to address warfighter needs, not only by maintaining the support infrastructure, but also by providing effective mechanisms for continued leverage of both national and industrial investments in HPC-based productivity.

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ACRONYMS

6-DOF	Six Degree-of-Freedom
AAC	Air Armament Center
ACLs	Access Control Lists
AEDC	Arnold Engineering Development Center
AFB	Air Force Base
AFIT	Air Force Institute of Technology
AFRL/IF	Air Force Research Laboratory Information Directorate
AFRL/SN	Air Force Research Laboratory Sensors Directorate
AHPCRC	Army High Performance Computing Research Center
AMCOM	US Army Aeroflightdynamics Directorate
ANSI	American National Standards Institute
ARC	Automotive Research Center
ARL	Army Research Laboratory
ARSC	Arctic Region Supercomputing Center
ASC	Aeronautical Systems Center
AT&T	American Telephone and Telegraph
ATM	Asynchronous Transfer Mode
CCM	Computational Chemistry and Materials Science
CEA	Computational Electromagnetics and Acoustics
CEMP	Coupled Environmental Model Prediction
CEN	Computational Electronics and Nanoelectronics
CERT	Computer Emergency Response Team
CFD	Computational Fluid Dynamics
CHSSI	Common High Performance Computing Software Support Initiative
COIL	Chemical Oxygen-Iodine Laser
COTS	Commercial-off-the-Shelf
CSM	Computational Structural Mechanics
CTA	Computational Technology Area
CWO	Climate/Weather/Ocean Modeling and Simulation
DCs	Distributed Centers
DFT	Density Functional Theory
DISA	Defense Information Systems Agency
DoD	Department of Defense
DREN	Defense Research and Engineering Network

DT&E	Development Test and Evaluation
DTC	Developmental Test Command
DTOs	Defense Technology Objectives
EOSFEL	Electro-Optical Sensor Flight Evaluation Laboratory
EQM	Environmental Quality Modeling and Simulation
ERDC	Engineer Research and Development Center
FMS	Forces Modeling and Simulation/C4I
GOTS	Government-off-the-Shelf
HPC	High Performance Computing
HPCMP	High Performance Computing Modernization Program
HWIL	Hardware-in-the-Loop
IHPTET	Integrated High Performance Turbine Engine Technology
IMT	Integrated Modeling and Test Environments
ISAR	Inverse Synthetic Aperture Radar
JET	Joint Engineering Taskforce
JID	Joint Intrusion Detection
JITC	Joint Interoperability Test Command
JNTF	Joint National Test Facility
JWCOs	Joint Warfighting Capability Objectives
JWSTP	Joint Warfighting Science and Technology Plan
LES	Large-Scale Eddy Simulation
MAEs	Metropolitan Area Exchanges
MEMS	Micro Electro Mechanical Systems
MHPCC	Maui High Performance Computing Center
MPI	Message Passing Interface
MSRCs	Major Shared Resource Centers
NAC	National Automotive Center
NAP	Network Access Point
NAVO	Naval Oceanographic Office
NAWCAD	Naval Air Warfare Center Aircraft Division
NAWCWD	Naval Air Warfare Center Weapons Division
NGI	Next Generation Internet
NGIXs	Next Generation Internet Exchanges
NIDS	Network Intrusion Detection Systems
NRL	Naval Research Laboratory
NUC	Non-Uniformity Correction
PET	Programming Environment and Training
RCS	Radar Cross Section

RTTC	Redstone Technical Test Center
S&T	Science and Technology
SAVs	Site Assistance Visit
SIP	Signal/Image Processing
SITREPs	Situation Reports
SMDC	Space and Missile Defense Command
SOVAS	Symbolically Optimized Vehicle Analysis System
SSAAs	System Security Authorization Agreements
SSC	Space and Naval Warfare Systems Center
T&E	Test and Evaluation
TARDEC	Tank Automotive Research, Development and Engineering Center
TBCs	Thermal Barrier Coatings
TGO	Thermally Grown Oxide
THAAD	Theater High Altitude Area Defense
vBNS	very high performance Backbone Network Service
VPF	Vector Product Format
VPG	Virtual Proving Ground
WAN	Wide Area Network
WRF	Weather Research and Forecast
WSMR	White Sands Missile Range



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